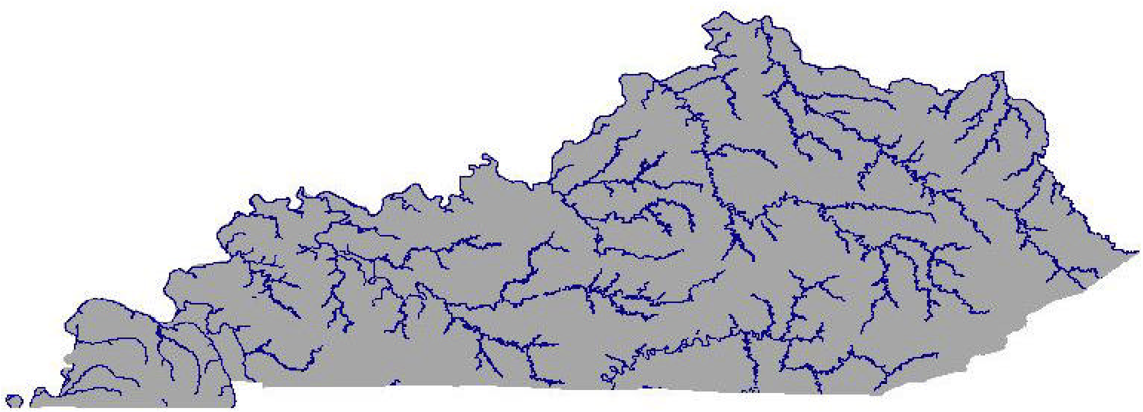
Pesticides in Kentucky Rivers



Natural Resources and
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Department for Environmental Protection
Division of Water

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PREFACE

This report documents pesticide presence and concentration in Kentucky's rivers. Pesticide information in this report is based on sampling conducted in 1996 and 1997. Information addressing which pesticides are present and the levels of concentration are compared with water quality criteria.

This report is the culmination of a concerted effort by field and central office personnel of the Division of Water who collected and organized the data and who typed, edited, and assembled the report.

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Scott Bryan, Division of Environmental Services (DES) Organic Branch Manager, was helpful in providing laboratory support and analytical information. Bill Davis, DES director, entered the analytical data electronically and provided quality assurance checks.

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I would like to thank the following persons for reviewing this report: Terry Anderson, Division of Water, Water Quality Branch Manager, Tom VanArsdall, Supervisor, Standards and Specifications Section, Water Quality Branch, and Allison Shipp, U.S. Geological Survey.

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EXECUTIVE SUMMARY

Agricultural usage accounts for 70 to 80 percent of total pesticide yearly usage in the United States. Little factual information existed regarding pesticide presence in Kentucky's rivers in the mid-1990's. To address this information gap, the Division of Water undertook a two year project in 1996 and 1997 to determine which pesticides and quantities of these pesticides were present in Kentucky's rivers. Over the course of the study, pesticide samples were collected at twenty-six sites. Individual samples were analyzed for ninety-four pesticides in 1996 and an additional twenty-four pesticides in 1997. The metabolite deethylatrazine (DEA) was also analyzed for in 1997. The most frequently detected pesticides were atrazine, metolachlor, simazine, alachlor, acetochlor, and 2,4-D. Atrazine was the most frequently detected pesticide in both years. In 1996 atrazine was detected at 95 percent of the sites and in 67 percent of the samples. In 1997 atrazine was detected at 100 percent of the sites and 90 percent of the samples. Metolachlor was detected at 86 percent of the sites in 1996 and in 41 percent of the samples. In 1997 metolachlor was detected at 100 percent of the sites and in 72 percent of the samples. Atrazine and metolachlor were the leading herbicides applied to corn acreage in both study years. Concentration levels were greatest in Kentucky's rivers following application to croplands in spring, and decreased to near background levels by fall. Concentration levels of atrazine varied by physiographic region. Atrazine levels were highest in the Jackson Purchase, Western Pennyroyal, and Western Kentucky Coal Field regions. These regions account for over half of the row crop production in Kentucky. Seasonally, atrazine exceeded the maximum contaminant level (3 µg/L) for drinking water and the Canadian aquatic life criteria (2 µg/L) in western Kentucky rivers. Lower levels of atrazine, were found in the Salt River and Licking River watersheds. Rivers of the Eastern Kentucky Coal Field had atrazine levels at or below the atrazine reporting level. Criteria were not exceeded in rivers of central and eastern Kentucky.

INTRODUCTION

Pesticides are used to increase crop production, lower maintenance costs, and control public health hazards. The majority of pesticide use is in agriculture, accounting for 70 to 80 percent of total pesticide usage yearly. The Ohio River Valley Water Sanitation Commission (ORSANCO) estimated that in 1994, 70 million pounds of five herbicides (atrazine, metolachlor, alachlor, cyanazine, and simazine) were applied to corn and soybean acreage in the lower Ohio River basin (ORSANCO, 1997).

Figures 1 and 2 list the top 15 pesticides (excluding growth regulators) applied to Kentucky croplands in 1996 and 1997. Atrazine, metolachlor, glyphosate, acetochlor, and pendimethalin were the five most heavily applied pesticides in both years. As a group, they represent 4.72 million pounds of applied product in 1996 and 4.54 million pounds of applied product in 1997. Acephate was the leading insecticide in both years. It is estimated that 9.3 million pounds of pesticides were sold in Kentucky in 1996, and 8.9 million pounds of pesticides were sold in 1997 (Kentucky Department of Agriculture, Division of Pesticides, 1997, 1998).

Annual stream loads of pesticide parent compounds (not including degradation products) generally account for less than 2 percent of the amounts applied agriculturally in watersheds. For several herbicides, including atrazine, cyanazine, and metolachlor, the amount transported in streams consistently represents about 1 percent of the amount applied in watersheds (U.S. Geological Survey, 1999). Using the rate of herbicide loss to surface waters of 1 percent, it is estimated that 32,200 and 30,000 pounds of atrazine, metolachlor, and cyanazine combined were lost from cropland acreage to Kentucky rivers in 1996 and 1997, respectively. To assess the presence and potential impacts of pesticides to Kentucky rivers, the Kentucky Division of Water (KYDOW) initiated a two- year pesticide monitoring study. In 1996, the study was funded through a Section 319(h) Nonpoint Source implementation grant. The second year of the study was funded through Section 106 of the Clean Water Act. The goal of the study was to provide scientifically defensible information addressing pesticides in Kentucky's rivers.

The objectives of the study were to:

- identify the pesticides present in Kentucky rivers;
- quantify pesticide concentrations;
- assess potential adverse effects of pesticides to human health;
- assess potential adverse effects of pesticides to aquatic life; and
- store pesticide data in the U.S. Environmental Protection Agency (USEPA) water quality storage and retrieval database (STORET).

Figure 1. Pesticides Applied to Kentucky Croplands in 1996

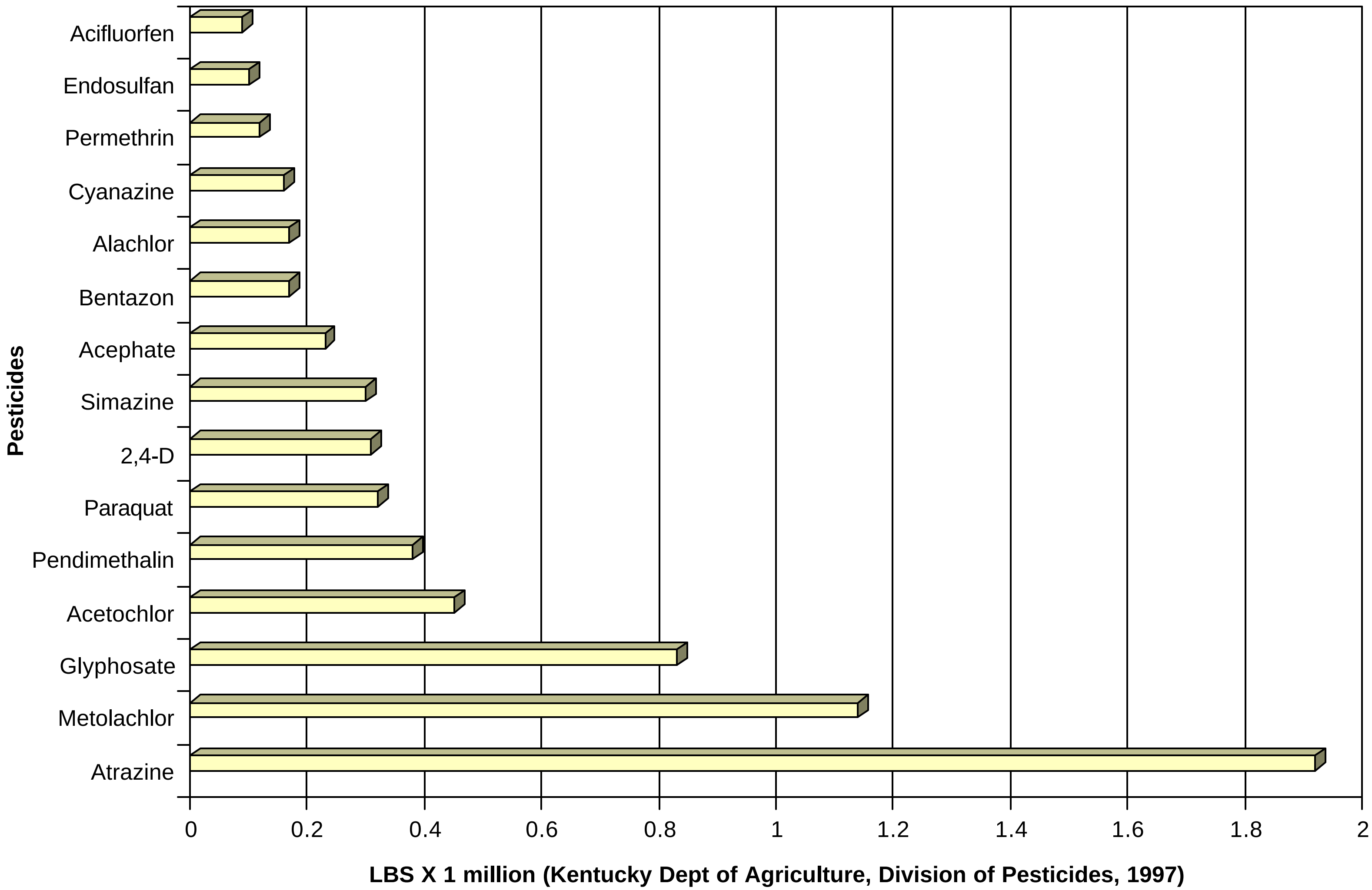
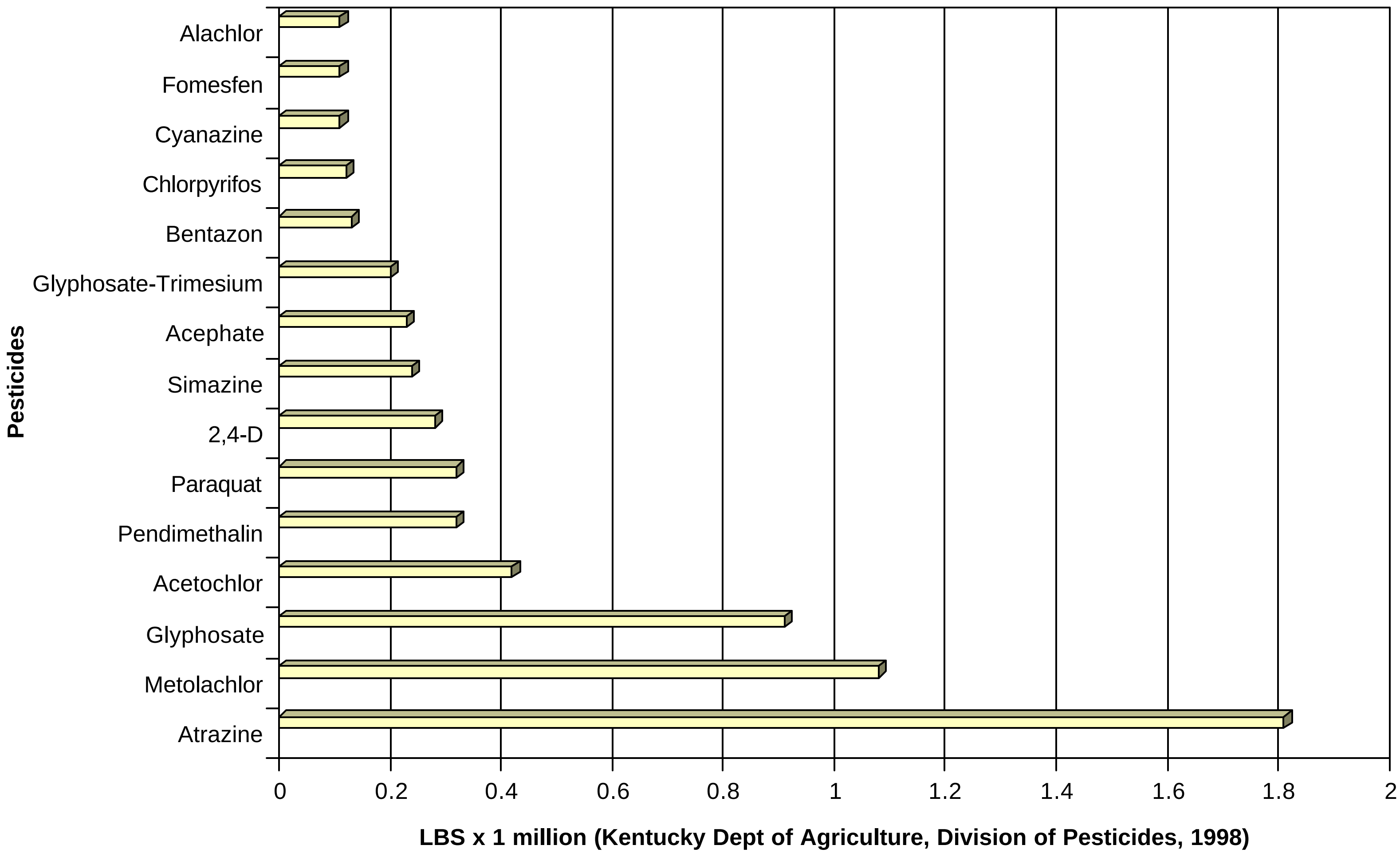


Figure 2. Pesticides Applied to Kentucky Croplands in 1997



Properties of Pesticides

Physicochemical properties of pesticides, as well as other factors such as usage, rainfall, and farming practices, are important in governing the amounts of pesticides that occur in streams. These physicochemical properties include water solubility, field dissipation half-life, and soil sorption coefficient (K_{oc}). Water solubility determines how easily pesticides wash off soil and crop residues and how easily they leach through the soil. Field dissipation half-life is the length of time required for pesticides to degrade in the soil to one-half their previous concentration. The longer the half-life the more persistent the pesticide. A longer half-life allows for a greater period of time for pesticide loss from soil to receiving waters. Soil sorption coefficient is a measure of the tendency of a pesticide to attach to soil particles. The higher the coefficient the more strongly the pesticide will be adsorbed to soil. Herbicides with solubilities greater than 30 mg/L, K_{oc} less than 300, and field dissipation half-lives longer than 21 days are considered to be mobile and persistent in water (Becker and others, 1989). Table 1 lists physicochemical properties for the most frequently detected pesticides (atrazine, metolachlor, simazine, alachlor, acetochlor, and 2,4-D.). Physicochemical properties of pendimethalin, a frequently applied pesticide used primarily in tobacco and corn production, are also listed. Though frequently applied, this pesticide was infrequently detected.

Table 1. Physicochemical Properties[1] of the Five Most Frequently Detected Pesticides.

Herbicide	Solubility (mg/L)	Field dissipation half-life (days)	K_{oc}
Atrazine	33	173	147
Metolachlor	488	141	70
Simazine	6.2	89	140
Alachlor	239	27	124
Acetochlor[2]	223	14	239
2,4-D ACID	890	14	20
Pendimethalin	.275	174	5000

[1] U.S. Department of Agriculture-Agricultural Research Service (USDA-ARS) Pesticide Properties Database, 1995

[2] U.S. Environmental Protection Agency (1994)

As a group, the commonly used triazine and acetanilide herbicides (i.e. atrazine, metolachlor, acetochlor, simazine) have moderate to high water solubility and relatively low soil sorption coefficients, and several are relatively persistent in soil. As a result, they have a moderate to high potential for loss from fields through surface runoff, primarily in the dissolved phase. In addition, most are chemically stable in water and unlikely to volatilize from water. In general, triazines are somewhat more resistant to biodegradation than acetanilides (Larson and others, 1997).

METHODS

Network Design

The 1996 sampling schedule was based on the frequency of sampling followed by the Illinois Pesticide Monitoring Subnetwork (Moyer and Cross 1990). After the first year's sampling, pesticide usage in western Kentucky was discussed with Dr. Jim Martin, University of Kentucky Agricultural Experimental Station, Princeton, who suggested the schedule followed in 1997. A listing of sample sites is presented in Table 2. Locations of sample sites are depicted in Figure 3. Samples were analyzed for 94 pesticides in 1996. An additional 24 pesticides and the metabolite deethylatrazine (DEA) were analyzed in 1997. In addition to the analysis of pesticides, samples were also analyzed for nine aroclors. Compounds analyzed during this study are presented in Appendix A.

Samples were collected at 21 sites in 1996 during pre-application (March-April), post-application (June) and fall (September - October) periods. In 1997, samples were collected at 22 sites in April, May, June, July, and fall (October - November). Three sites sampled in the Eastern Kentucky Coal Field in 1996 (Cumberland River at Cumberland Falls, Little Sandy River at Argillite, Levisa Fork near Louisa) were discontinued in 1997. Four sites in western Kentucky (Obion Creek near Oakton, Panther Creek near Sorgho, Cypress Creek near Rumsey, Casey Creek near Waverly, Rough River at Livermore) not sampled in 1996 were established in 1997. This shift in site locations was based on the fact that the majority of intense row cropping occurs in western Kentucky (Table 3); therefore, greatest agricultural use of pesticides and possibility of impacts to the environment would be expected in this area of the state. Based on crop production data, 84 percent of the corn acreage planted and 93 percent of the soybean acreage planted in 1997 was in the western three Kentucky Agricultural Statistical Districts (Kentucky Agricultural Statistics Service, 1998). Results of the 1996 Eastern Kentucky Coal Field pesticide study supported this shift in site locations.

Sampling Procedures, Analytical Methods, and QA/QC

When stream depth exceeded safe wading conditions, depth-integrated samples were collected in mid-channel by using weighted bottle samplers from bridges and by boat. Where stream depth permitted, depth-integrated samples were collected in mid-channel by wading using a US DH-81 sampler. Under very low flow conditions, samples were collected directly into sample bottles. Three one-liter amber bottles were filled on each site visit. These bottles were designated for either USEPA Method 507, 508, or 515.1 analysis. A 120-ml amber glass bottle was also filled and acidified with monoacetic acid for analysis of USEPA Method 531.1. Field duplicates were collected on about 10 percent of the total samples collected. The director of the Division of Environmental Services reviewed data packages and quality control results from the samples analyzed by the Division of Environmental Services.

Table 2. Pesticide Monitoring Stations			
Map No.[1]	STORET ID No.	Station Name/Location	RMI[2]
1	PEST001	Obion Creek near Oakton, KY 123, Hickman Co.	12.0
2	PRI037	Bayou de Chien near Clinton, US 51, Hickman Co.	15.1
3	PRI068	Clarks River near Paducah, KY 3075, McCracken Co.	6.2
4	PRI053	Tradewater River near Sullivan, US60/641, Crittenden/Union coes.	15.1
5	PRI071	Highland Creek near Uniontown, KY 1637, Union Co.	5.4
6	PEST002	Casey Creek near Waverly, House Bridge Rd., Union Co.	2.1
7	PRI070	Panther Creek near Sorgho, KY 56, Daviess Co.	5.4
8	PEST004	Cypress Creek near Rumsey, KY 939, McLean Co.	3.1
9	PRI012	Pond River near Sacramento, KY 85, Hopkins/McLean coes.	12.4
10	PRI055	Green River near Livermore, NA, McLean/Ohio coes.	72.0
11	PRI054	Rough River near Livermore, NA, McLean/Ohio coes.	1.0
12	PRI043	Little River near Cadiz, KY 272, Trigg Co.	24.4
13	PRI069	Red River near Keysburg, TN 161, Robertson Co. (TN)	49.0
14	PRI074	Drakes Creek near Bowling Green, Old Scottsville Rd., Warren Co.	8.0
15	PRI018	Green River at Munfordville, US 31 W, Hart Co.	225.7
16	PEST003	Nolin River at Millerstown, KY 224, Grayson/Hart coes.	59.2
17	PRI029	Salt River at Shepherdsville, KY 61, Bullitt Co.	22.9
18	PRI052	Salt River at Glensboro, KY 53, Anderson Co.	82.5
19	PRI057	Rolling Fork near Lebanon Junction, KY 61, Bullitt/Hardin coes.	12.3
20	PRI041	Beech Fork near Maud, KY 55, Nelson/Washington coes.	48.0
21	PRI060	Licking River at Claysville, US 62, Harrison Co.	78.2
22	PRI061	North Fork Licking River near Milford, KY 539, Bracken Co.	5.4
23	PRI059	South Fork Licking River at Morgan, KY 1054, Pendleton Co.	11.7
24	PRI009	Cumberland River at Cumberland Falls, KY 90, McCreary/Whitley coes.	562.6
25	PRI049	Little Sandy River near Argillite, KY 1, Greenup Co.	13.2
26	PRI064	Levisa Fork near Louisa, KY 644, Lawrence Co.	29.6

[1]See Figure 3
[2]RMI - River Mile Index

Figure 3. Pesticide Stations Monitored in 1996-1997

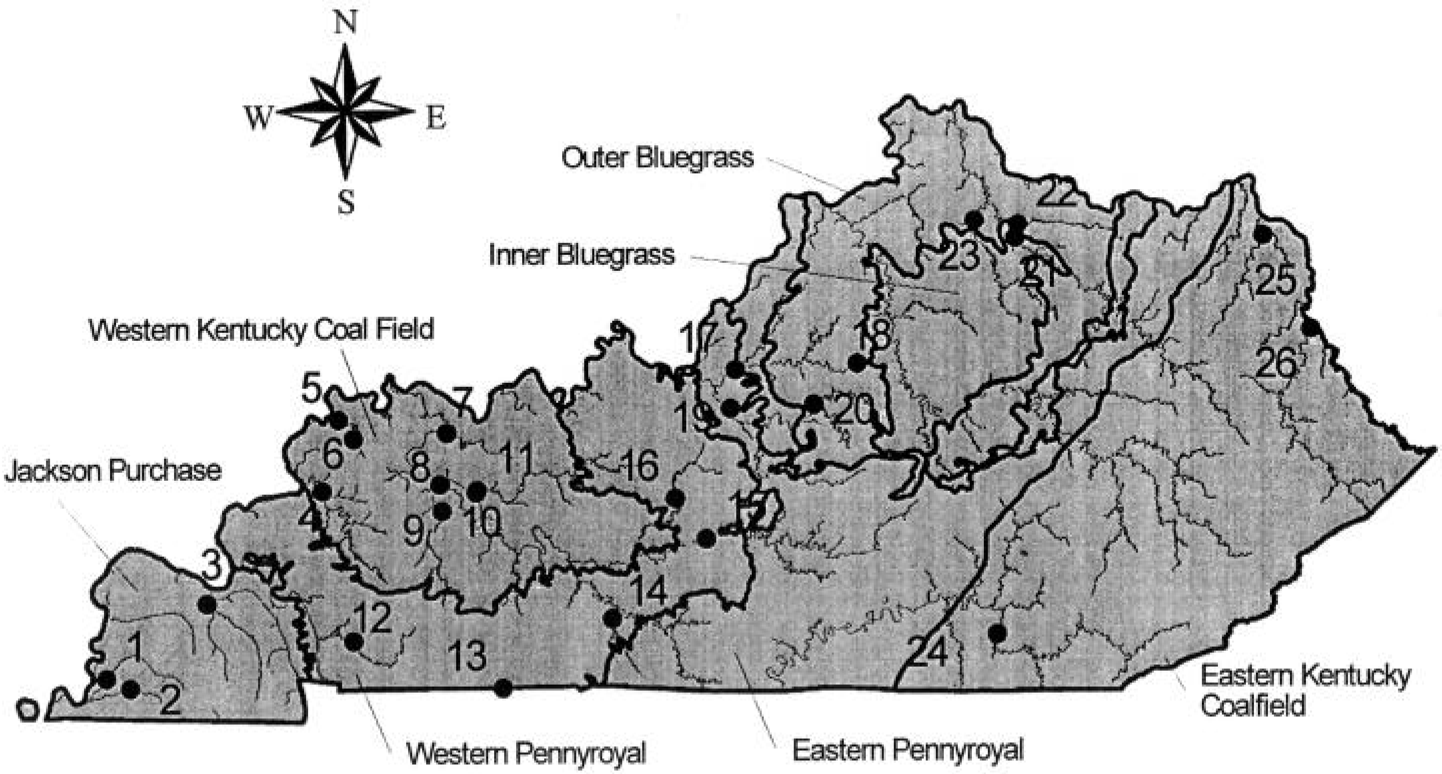


Table 3. Land Use[1] and Instream Atrazine Levels of Pesticide Monitoring Stations

STORET number	Station name	Drainage area (sq. mi.)	Percentage of watershed in row crops	Atrazine Growing Season Median (μg/L) ('97 April –July)
Jackson Purchase Region				
PEST001	Obion Creek near Oakton	321	32.9	4.04
PRI037	Bayou de Chien near Clinton	204	37.3	0.51
PRI068	Clarks River near Paducah	550	22.4	4.06
Western Kentucky Coal Field Region				
PRI053	Tradewater River near Sullivan	951	24.2	0.79
PRI071	Highland Creek near Uniontown	234	56.7	2.14
PEST002	Casey Creek near Waverly	31	61.3	1.04
PRI070	Panther Creek near Sorgho	382	38.0	0.50
PEST004	Cypress Creek near Rumsey	159	37.5	0.48
PRI012	Pond River near Sacramento	797	28.8	0.54
PRI055	Green River near Livermore	1020	18.3	0.26
PRI054	Rough River near Livermore	620	23.3	0.42
Western Pennyroyal Region				
PRI043	Little River near Cadiz	387	31.1	0.68
PRI069	Red River near Keysburg	342 (in KY)	39.7	0.49
PRI074	Drakes Creek near Bowling Green	309	23.8	0.07
PRI018	Green River near Munfordville	1254	13.8	0.12
PEST003	Nolin River at Millerstown	429	23.4	0.95
Salt River Watershed				
PRI029	Salt River at Shepherdsville	886	26.4	0.67
PRI052	Salt River at Glensboro	174	14.1	0.48
PRI057	Rolling Fork near Lebanon Jct.	1454	8.7	0.10
PRI041	Beech Fork near Maud	470	6.8	0.08
Licking River Watershed				
PRI061	Licking River at Claysville	1169	9.4	0.04
PRI060	NF Licking River near Milford	305	12.2	0.35
PRI059	SF Licking River at Morgan	928	13.4	0.05
Eastern Kentucky Coal Field Region				
PRI009	Cumberland River at Cumberland Falls	1648	0.5	*0.048 ('96)
PRI049	Little Sandy River at Argillite	724	2.2	*0.065 ('96)
PRI064	Levisa Fork near Louisa	1455	.07	Not detected

[1]See Appendix C for complete land use information.
****June sample (only detection, see Appendix E)***

Land Use Information

The Kentucky Land Use Data Set Version 98-07 developed by personnel at the EROS Data Center (EDC), Sioux Falls, South Dakota and the Rocky Mountain Mapping Center, Denver, Colorado, was the source of the land use information utilized by this report. Questions regarding the data set can be directed to Terry Sohl, (EDC; email sohl@edcmail.cr.usgs.gov; telephone 605-594-6537). Land use information for the watersheds monitored in this report is presented in Appendix C.

Data Analysis Protocol

To assess atrazine concentrations among Kentucky rivers, box and whisker plots were produced for all sample sites (excluding sites in the Eastern Kentucky Coal Field where low detection rate limited use of graphical presentation). Box and whisker plots are a graphical approach to illustrate summary information. The box represents the inter-quartile range (IR) (25^{th} to 75^{th} percentiles). A line represents the median across the inter-quartile range box. The whiskers represent the 10^{th} and 90^{th} percentiles of the data distribution. Numbers above the box plots in parentheses indicate number of observations used in preparing plots. When available, data for both years were combined during the plot production. Plots of the summary information are grouped by physiographic region. The maximum contaminant level (MCL) for drinking water and Canadian aquatic life protection criteria for atrazine are depicted on each plot. Graphical presentations of summary statistics were developed using the software package WQHYDRO. Other pesticides were not detected at a high enough frequency to analyze using this technique.

Water Quality Criteria for Pesticides

Water quality criteria are guidelines that are often incorporated into water quality standards for the protection of stream uses. Water quality criteria are estimates of concentrations in water below which adverse effects on human health or aquatic life are not expected to occur.

Current standards and guidelines do not completely eliminate risks because: (1) values are not established for many pesticides, (2) mixtures and breakdown products are not considered, (3) the effects of seasonal exposure to high concentrations have not been established, and (4) some types of potential effects, such as endocrine disruption and unique responses of sensitive individuals, have not yet been assessed (Fuhrer and others, 1999).

Different types of criteria have different sampling and analytical requirements. For example, USEPA chronic water quality criteria for protection of aquatic organisms are designed for comparison with 4-day average concentration of a contaminant in a water body. The drinking water MCL is the maximum annual average concentration of a contaminant allowed in water that is delivered to any user of a public water system after treatment. The type of sampling in this study was not intended to address regulatory actions but to be used as an indicator of potential water quality problems.

Table 4 presents aquatic life and human health criteria for the pesticides detected in this study. Appendix D compares USEPA and Canadian aquatic life criteria.

Table 4. Water Quality Criteria for Pesticides Detected in Kentucky Rivers (1996 - 1997)

Pesticide	**Criteria for human and aquatic health** MCL[1] (µg/L)	Lifetime HA[2] (µg/L)	Protection aquatic life [3] (µg/L)
Herbicides			
2,4-D	70	70	4 (Canada)
acetochlor	nsg[4]	nsg	nsg
alachlor	2	nsg	nsg
atrazine	3	200	2 (Canada)
cyanazine	nsg	1	2 (Canada)
dicamba	nsg	200	10 (Canada)
EPTC	nsg	nsg	nsg
metolachlor	nsg	100	8 (Canada)
metribuzin	nsg	200	1 (Canada)
pebulate	nsg	nsg	nsg
pendimethalin	nsg	nsg	nsg
prometon	nsg	100	nsg
simazine	4	4	10 (Canada)
terbacil	nsg	90	nsg
Insecticides			
diazinon	nsg	0.6	0.08 (Great Lakes)

[1] MCL - Maximum Contaminant Level for drinking water established by the U.S. Environmental Protection Agency (USEPA); apply to finished drinking water supplied by a community water supply; requires that the annual average concentration of a specific contaminant be below the MCL. Kentucky's drinking water regulations may be accessed via the internet at: http://water.nr.state.ky.us/DW/regulati.htm.

Lifetime HA - Health advisory level for drinking water established by the USEPA (for a 70-kilogram individual over a 70-year exposure period).

[3] Protective aquatic life criteria: Canadian water-quality guidelines (Canada) (Council of Resource and Environmental Ministers, 1996); Great Lakes water-quality objectives (Great Lakes) (International Joint Commission Canada and United States, 1977); all criteria values are for freshwater.

[4] nsg - no suggested value

RESULTS AND DISCUSSION

Pesticides Detected

The pesticides detected most frequently and in greatest concentrations were the most extensively used compounds with low soil sorption coefficient values such as atrazine and metolachlor. Table 5 presents frequency information for pesticides detected in 1996 and 1997. In 1996, ten pesticides were detected in the water-column. In 1997, fourteen pesticides were detected. Nine of the pesticides were detected in both years. Terbacil was detected once in 1996. Five pesticides (pendimethalin, EPTC, prometon, pebulate, diazinon) were detected only in 1997 (these pesticides were not analyzed in 1996). There were no detections of pesticides in either USEPA method series 508 or 531.1. Additionally, no aroclors (PCBs) were detected either year. Concentrations of the pesticides detected during the study are shown in Figure 4. The dot plot shows the distribution and range in concentration for each pesticide over the period of study. Each dot represents one sample. Laboratory results for 1996 and 1997 are provided in appendices E and F. Appendix B provides information on brand names of these pesticides, what crops they are used on and what they control.

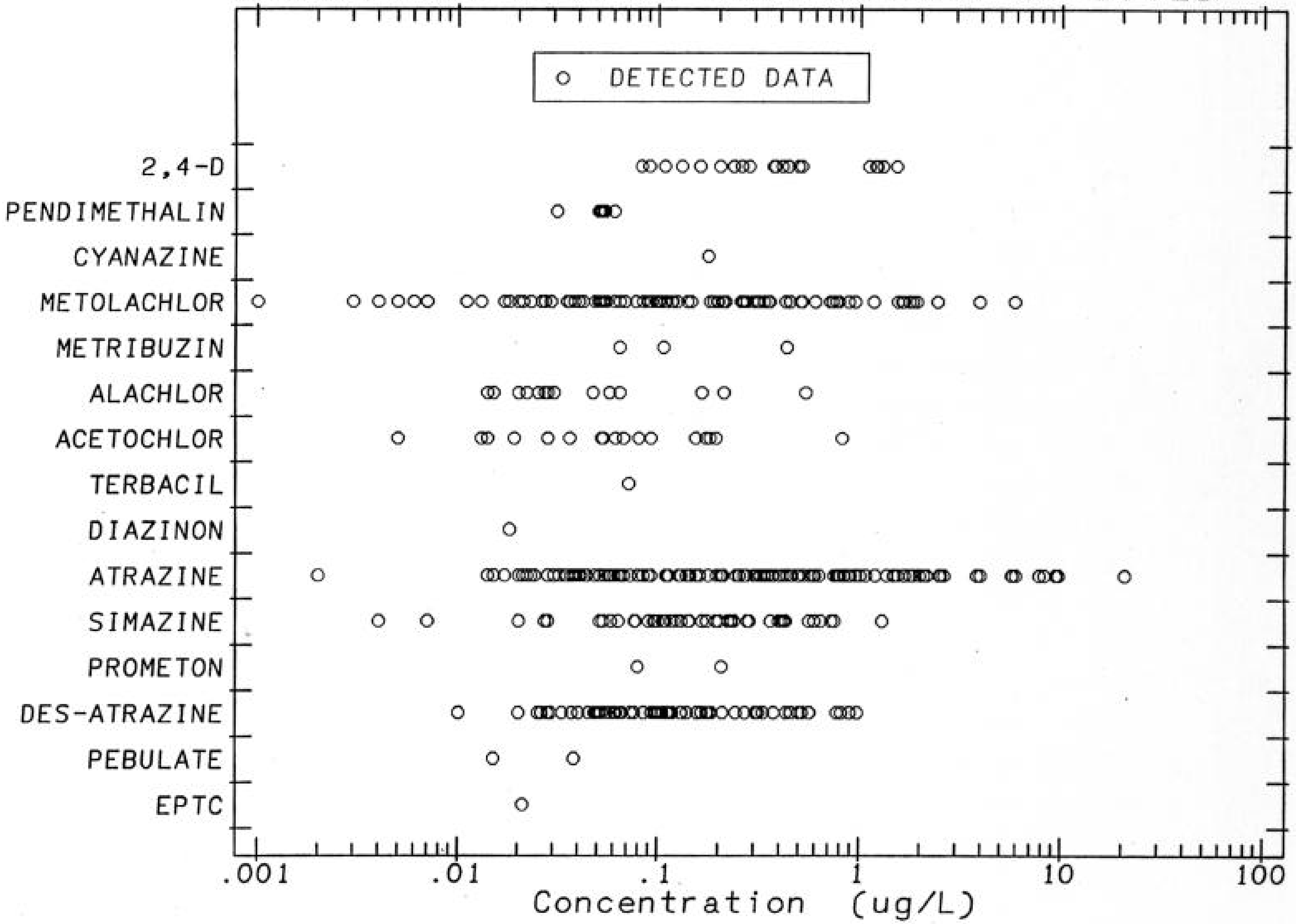
Atrazine was the most frequently detected pesticide in both years. In 1996, atrazine was detected at 95 percent of the sites sampled and in 67 percent of the samples. In 1997, atrazine was detected at 100 percent of the sites sampled and in 90 percent of the samples. Metolachlor was detected at 86 percent of the sites sampled and in 41 percent of samples in 1996. In 1997, metolachlor was detected at 100 percent of the sites sampled and in 72 percent of the samples. Atrazine and metolachlor were the leading herbicides applied to corn acreage in 1996. These pesticides were applied to 94 percent and 40 percent of corn acreage respectively. Simazine, the third leading corn herbicide, was detected at 71 percent of the sites sampled in 1996 and 91 percent of sites sampled in 1997. Simazine was present in 27 percent of the samples in 1996 and 30 percent of the samples in 1997. Acetochlor is increasingly being applied to corn acreage in Kentucky. Pesticide sales data for 1996 list acetochlor as the fifth leading pesticide (448,000 pounds) sold in Kentucky (Kentucky Department of Agriculture, 1997). This is in contrast to 1995 sales data which placed acetochlor fourteenth (200,000 pounds sold). Acetochlor was registered for use on corn in 1994. Acetochlor is mixed with atrazine and sold as the product Harness Xtra. In 1997, acetochlor was detected at 56 percent of the sites compared to 24 percent of the sites in 1996. Acetochlor was detected in 21 percent of the samples in 1997, compared to 8 percent in 1996. While the use of acetochlor has been increasing, the use of alachlor has decreased. In 1996, alachlor was detected at 43 percent of the sites, while in 1997, it was detected at 17 percent of the sites.

Breakdown Products

DEA (an atrazine metabolite) was detected at 96 percent of sites sampled and 90 percent of samples in 1997. DEA was not analyzed for in 1996.

TABLE 5 . PESTICIDE FREQUENCY OF DETECTION IN WATER COLUMN							
Study		Sites			Samples		
Year	Compound	Practical quantification limit (µg/L)	Number of sites	Percent of sites with detections	Number of samples	Percent of samples with detections	Maximum concentration (µg/L)
1996	2,4-D	.1	21	33	63	11	1.51
	Acetochlor	.05	21	24	63	8	0.286
	Alachlor	.05	21	43	63	14	0.164
	Atrazine	.05	21	95	63	67	3.81
	Cyanazine	.05	21	5	63	2	0.151
	Dicamba	.05	21	5	63	2	0.041
	Metolachlor	.05	21	86	63	41	0.515
	Metribuzin	*.05*	*21*	*5*	*63*	*2*	*0.064*
	Simazine	.05	21	71	63	27	1.29
	Terbacil	.1	21	5	63	2	0.071
1997	2,4-D	.1	23	43	115	13	4.08
	Acetochlor	.05	23	56	115	21	0.815
	Alachlor	.05	23	17	115	4	0.537
	Atrazine	.05	23	100	115	90	20.6
	Atrazine,desethyl	.05	23	96	115	78	0.969
	Cyanazine	.05	23	17	115	3	1.24
	Diazinon	.05	23	9	115	2	0.018
	Dicamba	*.05*	*23*	*4*	*115*	*1*	*0.105*
	EPTC	.05	23	4	115	1	0.021
	Metolachlor	.05	23	100	115	72	5.87
	Metribuzin	.05	23	9	115	2	0.432
	Pebulate	.05	23	9	115	2	0.105
	Pendimethalin	.05	23	4	115	1	0.031
	Prometon	.05	23	9	115	2	0.206
	Simazine	.05	23	91	115	30	0.747

FIGURE 4.
CONCENTRATIONS Of PESTICIDES DETECTED



Seasonal Patterns of Pesticide Occurrence

The first runoff-inducing rain event after application of a pesticide can potentially move significant amounts of the pesticide to surface waters. The seasonal pattern of instream pesticide concentration is depicted in Figure 5. From fall through late winter, pesticide concentrations are at or near background levels. Pesticide pre-application begins in March in western Kentucky and later in eastern Kentucky as soil conditions permit. Pesticide concentrations increase in streams as spring rains create runoff of the applied pesticides. Generally, peak concentrations are observed in May and June, with levels decreasing in July, returning to background levels in the fall. This seasonal pattern has been observed in numerous studies of midwestern rivers (Larson and others, 1997). Typical seasonal patterns were observed in 1996. However, in 1997 abnormal weather conditions resulted in a deviation from typical seasonal stream pesticide patterns in many of Kentucky's rivers. February had above normal temperatures the first, third, and fourth weeks of the month. Rainfall was normal for the month with above normal rainfall the fourth week. The early warm spell allowed farmers in western Kentucky to apply pre-emergent pesticides. The first week of March had an extreme surplus of rainfall leading to extensive flooding. Locations along the Ohio River suffered record and near-record flooding. The remainder of the spring was cooler and wetter than normal (Kentucky Agricultural Statistics, 1998). The heavy rains the last week of February and first week of March resulted in high April stream pesticide concentrations in several western Kentucky streams near the Ohio and Mississippi rivers (Appendix F).

Physiographic Region/Watershed Evaluations

Kentucky is divided into a number of physiographic regions: the Jackson Purchase, Western Pennyroyal, Eastern Pennyroyal, Western Kentucky Coal Field, Bluegrass, and Eastern Kentucky Coal Field regions. Pesticide detection information is presented regionally for the Jackson Purchase, Western Pennyroyal, Western Kentucky Coal Field, Bluegrass, and Eastern Kentucky Coal Field regions. Additionally, pesticide detection information is present for the Salt and Licking River watersheds. Yearly variations in pesticide presence and concentrations are discussed. Atrazine data is used to reflect differences between regions. Atrazine had the highest frequency of detection in both sampling years. Atrazine also exceeded drinking water and aquatic life criteria most frequently. Table 3 lists land use and median growing season instream atrazine levels by physiographic region. The median was calculated by substituting one-half (0.025 μg/L) of the practical quantification limit for nondetected values.

Jackson Purchase Region. The Jackson Purchase Region lies in Far Western Kentucky. The region is bounded to the east by the Tennessee River, the north by the Ohio River and the west by the Mississippi River. Two of the major soil resource areas for intensive row crop production lie in the Purchase Region - the Mississippi River Flood Plain and the Jackson Purchase Thick Loess Belt (Bailey, 1970). Agriculture in the Jackson Purchase is characterized by cash grain and hog production (Kentucky

Agricultural Statistics, 1998). Row cropland use of watersheds in this study is presented in Table 3. In 1996, corn acreage in the Purchase Region accounted for 15 percent of the state total. Soybean acreage planted in the Purchase in 1996 accounted for 25 percent of the state total. Winter wheat acreage planted in the Purchase in 1996 accounted for 20 percent of the state total. Burley tobacco acreage in the Purchase accounted for 1 percent of the state total acreage in 1996.

Six herbicides were detected in 1996 in Purchase area streams. The post-application sample from Bayou de Chien was lost due to bottle breakage. This is important because most detection's in 1996 samples were from the post-application sampling. In Clarks River, atrazine and metolachlor were detected in pre-application, post-application, and fall samples. Alachlor and terbacil were detected only in the post-application sample. 2,4-D was detected in the fall sample only.

Seven herbicides were detected in 1997 in Purchase Area streams. Metolachlor, atrazine, and the breakdown product DEA were detected in all samples from Clarks River and Obion Creek. These herbicides were present in all but the fall sample from Bayou de Chien.

Figure 6 presents box and whisker plots for rivers in the Jackson Purchase Region. Plots for Bayou de Chien and Clarks River represent combined data for 1996 and 1997. The plot for Obion Creek represents only 1997 data. The median value for Bayou de Chien was below 0.5 μg/L, while the median for Clarks River was slightly above 0.5 μg/L. The median for Obion Creek was above 2.0 μg/L, the chronic aquatic protection criterion value. The IR for Bayou de Chien was rather narrow; the 90^{th} percentile was less than 2.0 μg/L. The IR for Clarks River and Obion Creek exceeded both the MCL and chronic aquatic life criteria. The April atrazine concentration in Obion Creek (20.6 μg/L) was the highest recorded during the study.

Numerous excursions above the maximum contaminant level and aquatic life criteria were observed. All excursions occurred in 1997. While Obion Creek and Clarks River are not used as drinking water supplies, the MCL for atrazine was exceeded twice in each of these streams. The chronic aquatic life criterion for atrazine was exceeded twice in Obion Creek and three times in Clarks River. The 1997 growing season median values for Obion Creek in Clarks River exceeded both the drinking water and chronic aquatic life criteria.

Western Pennyroyal Region. The Western Pennyroyal Region lies in western Kentucky. The region forms an arc reaching an area between the confluences of the Cumberland and Tradewater rivers with the Ohio River, to the Kentucky/Tennessee border, and then northward to the Ohio River west of the Salt River watershed. Soils of the Western Pennyroyal Region lie in the Western Pennyroyal-Limestone and Western Pennyroyal - Sandstone, Shale, and Limestone resource areas (Bailey, 1970). The region is characterized by karst topography. Cash grain and livestock are the major agricultural

FIGURE 5. MONTHLY PESTICIDE CONCENTRATIONS IN HIGHLAND CREEK

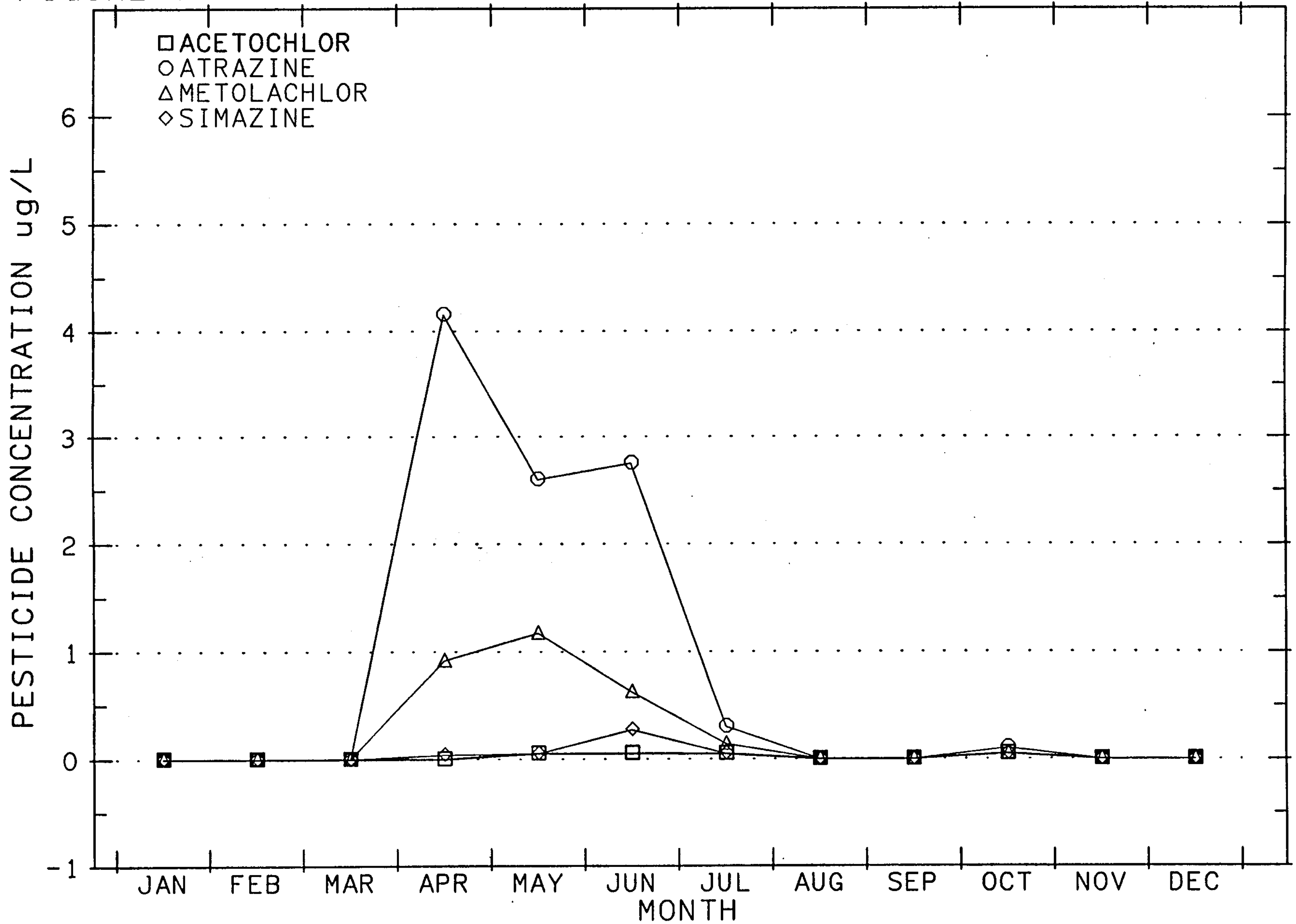
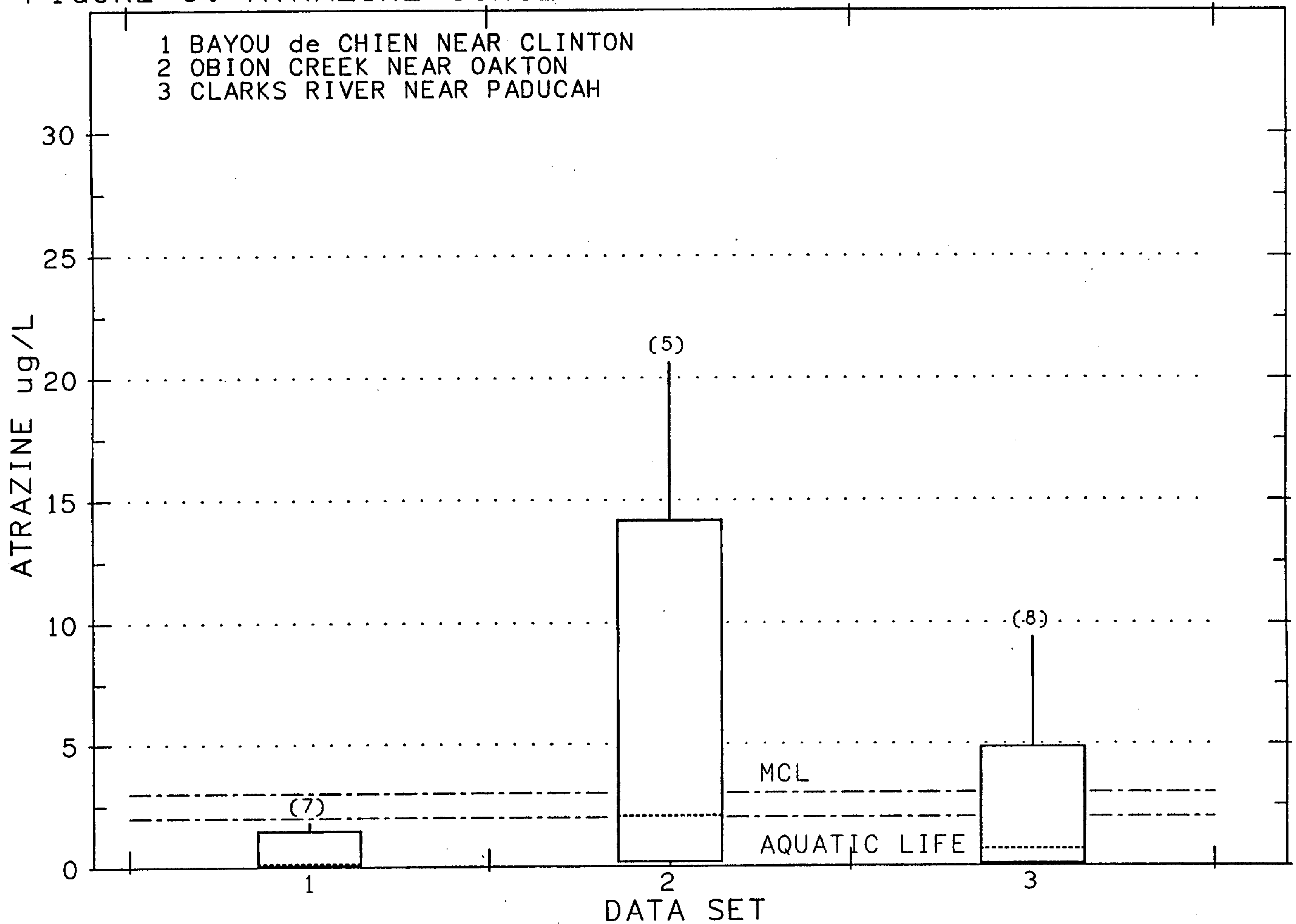


FIGURE 6. ATRAZINE CONCENTRATIONS - JACKSON PURCHASE REGION



products (Kentucky Agricultural Statistics, 1998). Row crop land use of watersheds in this study is presented in Table 3. In 1996, corn acreage in the Western Pennyroyal accounted for 32 percent of the state total; soybean acreage accounted for 29 percent of the state total.

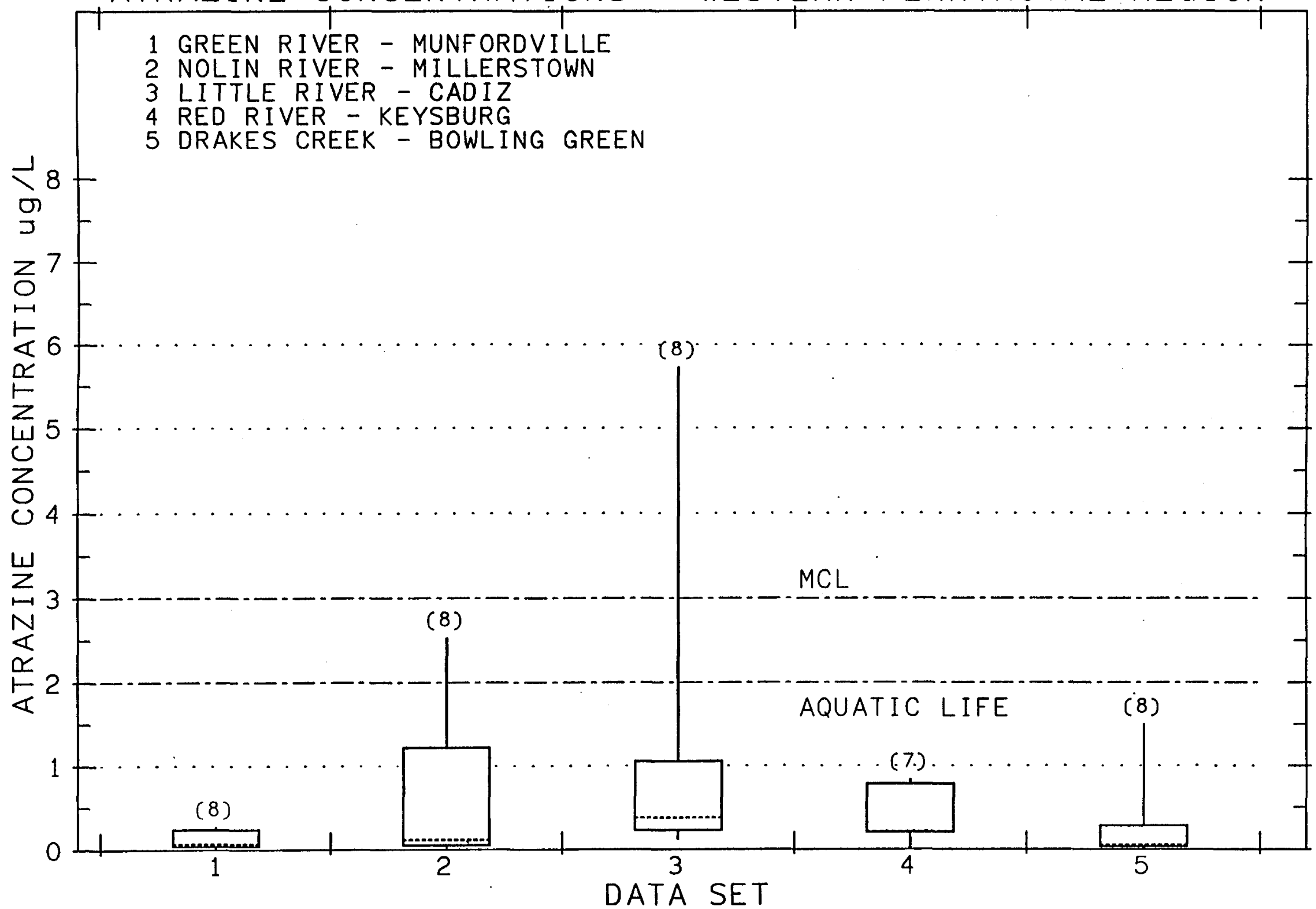
Seven herbicides were detected in 1996 in Western Pennyroyal streams. Atrazine was detected in all samples. Metolachlor was detected in all samples from Little River and Red River and in all but the fall sample from Nolin River. Metolachlor was detected only in the post-application samples from the Green River and Drakes Creek. Acetochlor, cyanazine, alachlor, and simazine were detected only in post-application samples.

Seven herbicides were detected in 1997 in Western Pennyroyal streams. Metolachlor, atrazine, and the breakdown product DEA were detected in most samples.

Figure 7 presents box and whisker plots for atrazine in rivers in the Western Pennyroyal Region. Median concentrations in all rivers were below 0.5 μg/L. The Nolin River, Little River, and Red River had the largest IRs. Cash grain farming is a major land use in these watersheds. Watersheds in the Western Pennyroyal are underlain by karst topography. Larson and others, (1997) noted that ground water may serve as a reservoir for pesticide storage, contributing to instream pesticide concentrations for periods long after surface runoff has subsided. The MCL for drinking water was exceeded once in the Little River in May 1997. The chronic aquatic life criterion for atrazine was exceeded once each in 1996 and 1997. In 1996, the atrazine criterion was exceeded in Nolin River. In 1997, the criterion was exceeded in the Little River.

Western Kentucky Coal Field Region. The Western Kentucky Coal Field Region lies in west central Kentucky. The region lies within the arc formed by the Western Pennyroyal Region. Roughly the region encompasses that area downstream of the confluence of the Green and Barren rivers. Included in this region are the Rough and Pond rivers, tributaries to the Green River, and Tradewater River. Soils of the Western Kentucky Coal Field lie in the Western Coal Fields - Valleys and Low Hills and Western Coal Fields - Hilly Uplands resource areas. Intensive row cropping is conducted in the broad river valleys of the Green River and its tributaries. Cash grain production is the principle agricultural activity, although poultry production has become increasingly important (Kentucky Agricultural Statistics, 1998). Geology of the region is characterized by alluvium over limestone, sandstone, and shale. Row crop land use of watersheds in this study is presented in Table 3. In 1996, corn acreage in the Western Kentucky Coal Field accounted for 32 percent of the state total; soybean acreage accounted for 36 percent of the state total; and winter wheat acreage accounted for 16 percent of the state total. Burley tobacco acreage planted in the Western Kentucky Coal Field in 1996 accounted for 5 percent of the state total acreage.

FIGURE 7.
ATRAZINE CONCENTRATIONS - WESTERN PENNYROYAL REGION



Seven herbicides were detected in 1996 in Western Kentucky Coal Field streams. Atrazine was detected in all post-application and fall samples. Metolachlor was detected in post-application and fall samples from Green River. Alachlor, simazine, 2,4-D, and metribuzin were detected only in post-application samples. Dicamba was detected in the pre-application sample from Tradewater River.

Eleven herbicides, the breakdown product DEA, and the insecticide diazinon were detected in 1997 in Western Kentucky Coal Field streams. Atrazine and metolachlor were detected in most samples. Acetochlor, alachlor, EPTC, dicamba, metribuzin, pendimethalin, prometon, and simazine were detected in post-application samples.

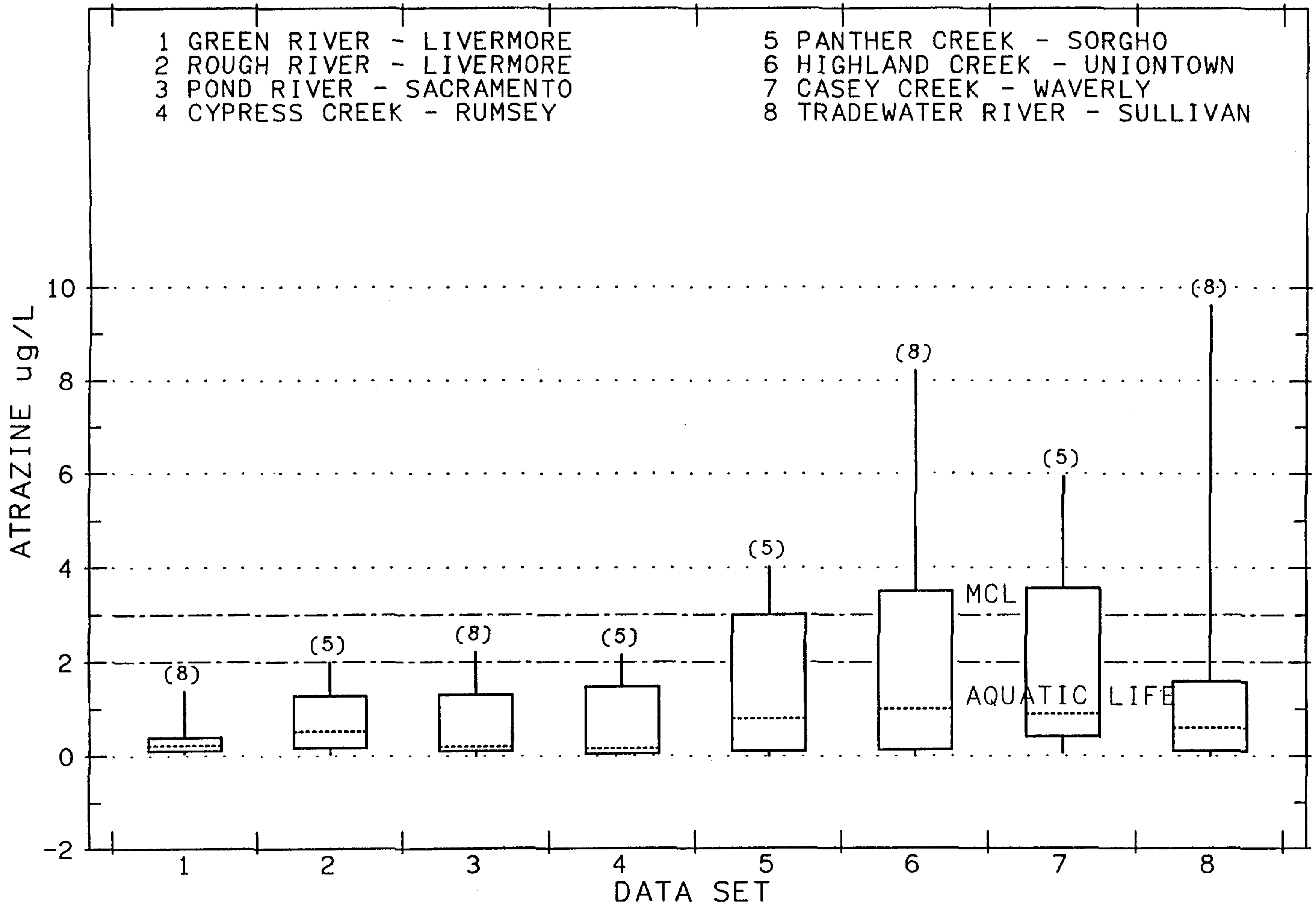
Figure 8 presents box and whisker plots for atrazine in rivers in the Western Kentucky Coal Field. Plots for Green River at Livermore, Pond River, Highland Creek, and Tradewater River represent combined data for 1996 and 1997. Plots for Rough River, Cypress Creek, Panther Creek, and Casey Creek represent 1997 data only. Median atrazine concentrations were below 1.0 μg/L for all sites with the exception of Highland Creek. The median for Highland Creek was slightly above 1.0 μg/L. The IRs for Green River at Livermore, Rough River, Pond River, Cypress Creek, and Tradewater River were all below the MCL and aquatic criteria. Inter-quartile ranges for Panther Creek, Highland Creek, and Casey Creek overlapped the aquatic life protection criterion. Inter-quartile ranges for Highland Creek and Casey Creek overlapped the MCL for drinking water.

The drinking water MCL for atrazine was exceeded once in 1996 in Highland Creek. In 1997, the criterion was exceeded once each in Panther Creek, Highland Creek, Casey Creek, and Tradewater River. Of these streams, Tradewater River is the only one used as a drinking water supply. The May 1997 atrazine concentration for the Tradewater River was 9.65 μg/L. Although the MCL is based on the annual average concentration, results indicate that atrazine levels seasonally do exceed the MCL. The calculated annual average atrazine concentration for the Tradewater River in 1997 was 1.00 μg/L.

The aquatic life criterion for atrazine was exceeded once each in Pond River and Highland Creek in 1996. In 1997, the criterion was exceeded twice in Highland Creek, and once each in Cypress Creek, Panther Creek, Casey Creek, and Tradewater River. The criterion was approached but not exceeded in Rough River in 1997.

Salt River Watershed. The Salt River watershed lies in central Kentucky between the Green and Kentucky River watersheds to the south and east of Louisville. Soils of the Salt River watershed lie in the Knobs, Outer Bluegrass, and Hills of the Bluegrass resource areas (Bailey, 1970). The region is characterized by limestone and shale geology.

FIGURE 8.
ATRAZINE CONCENTRATIONS - WESTERN KENTUCKY COAL FIELD REGION



The Outer Bluegrass and the river bottoms of the Rolling Fork are important agricultural areas for livestock and tobacco. Most farms are general-purpose operations, comprised of a mix of forage, tobacco, and grain crop production. Generally, use of pesticides is confined to corn, soybean, tobacco, alfalfa and wheat fields. On a total acreage basis, this represents a fairly small portion of the landscape. The Hills of the Bluegrass subregion is characterized by highly dissected topography. General farming, with tobacco and beef production predominating, is the principal farming type. Only scattered small fields of tobacco, and corn are treated with pesticides. Row crop land use of watersheds in this study is presented in Table 3. In 1996, corn acreage in the Salt River watershed accounted for 6 percent of the state total; soybean acreage accounted for 4 percent of the state total; winter wheat accounted for 6 percent of the state total; and burley tobacco acreage accounted for 11% of the state total.

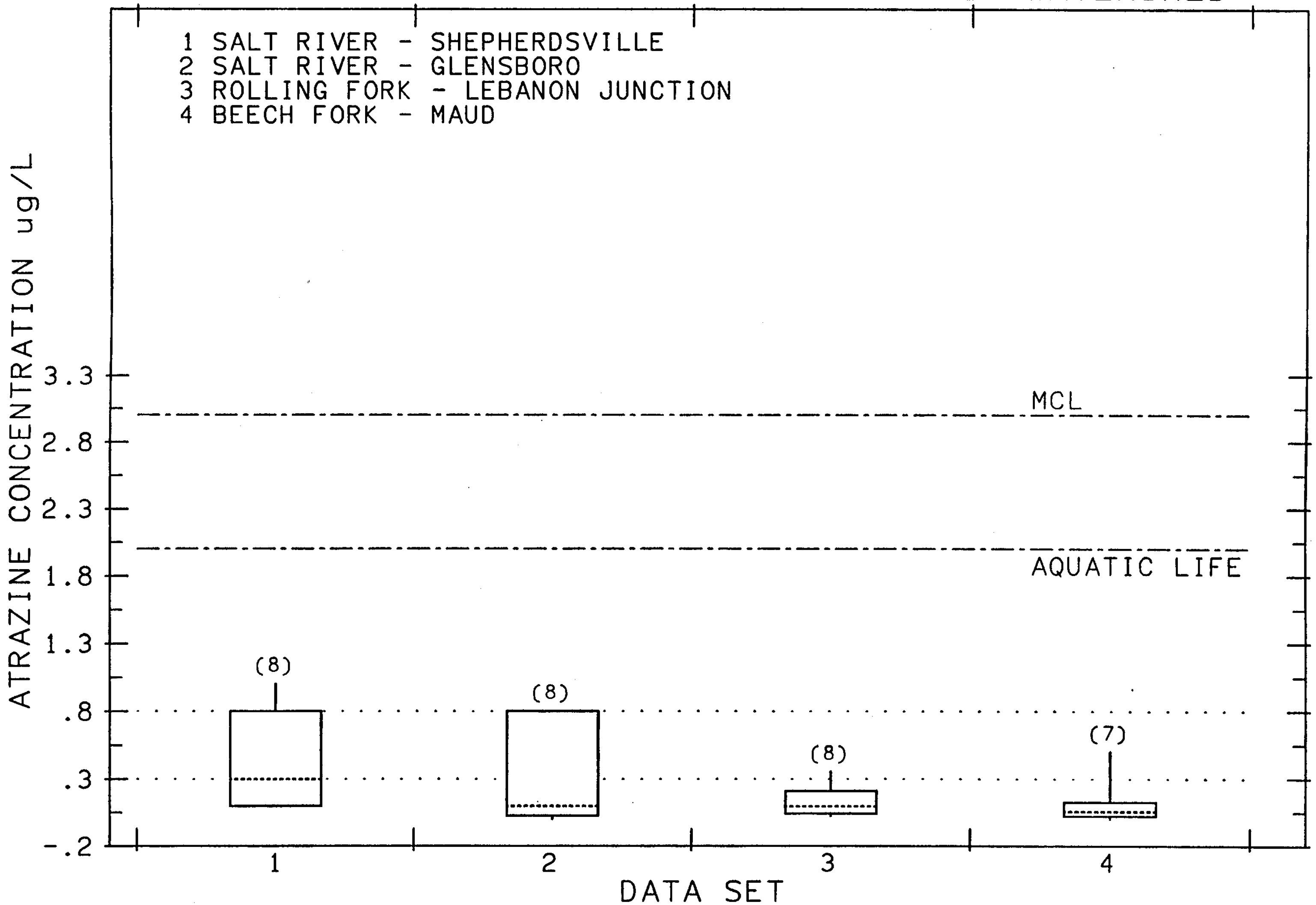
Five herbicides were detected in 1996 in the Salt River watershed. Atrazine was detected in post-application and fall samples in Salt River (both sites) and Rolling Fork. In Beech Fork atrazine was detected in spring and post-application samples. Acetochlor, alachlor, metolachlor, and simazine were detected only in post-application samples.

Six herbicides (acetochlor, atrazine, metolachlor, prometon, simazine, 2,4-D), the breakdown product DEA, and the insecticide diazinon were detected in 1997 in the Salt River watershed.

Figure 9 presents box and whisker plots for atrazine in the rivers in the Salt River Watershed. Median concentrations in all rivers were below 0.5 μg/L. The Salt River at Shepherdsville and the Salt River at Glensboro exhibited the greatest IRs. The MCL and aquatic life criteria were not exceeded at any of the monitoring sites.

Licking River Watershed. The Licking River watershed lies in east central Kentucky east of the Kentucky River watershed. Although headwaters begin in the Eastern Kentucky Coal Field, the watershed lies generally west of this region. The portion of the watershed addressed in this report lies downstream of Cave Run Lake, a 8,210 acre reservoir formed by the damming of Licking River at River Mile 173.6. Soils of the Licking River watershed downstream of Cave Run Lake, excluding the South Fork Licking River watershed headwaters, lie in the Knobs, Outer Bluegrass, and Hills of the Bluegrass subregions of the Bluegrass Region. Land use of these subregions was discussed under the Salt River Watershed. The South Fork Licking River headwaters lie in the Inner Bluegrass subregion. Land use in the Inner Bluegrass is similar to the Outer Bluegrass with the notable exception of extensive acres devoted to horse production. Row crop land use of watersheds in this study is presented in Table 3. In 1996, corn acreage in the Licking River watershed downstream of Cave Run Lake accounted for 5 percent of the state total; soybean acreage accounted for 2 percent of the state total; winter wheat

FIGURE 9.
ATRAZINE CONCENTRATIONS - SALT RIVER WATERSHED



accounted for 4 percent of the state total; and burley tobacco acreage accounted for 19% of the state total.

Five herbicides were detected in 1996 in the Licking River watershed. Atrazine was detected in post-application and fall samples from the North Fork and South Fork, but was present only in the post-application in the Licking River. 2,4-D was detected in the pre-application and fall samples in the North Fork and South Fork. Alachlor, metolachlor, and simazine were detected only in post-application samples.

Six herbicides and the breakdown product DEA were detected in 1997. Atrazine was not detected in the April sample from any of the sites and was absent from the fall sample from the North Fork. Most detections occurred in June and included in addition to atrazine: acetochlor, metolachlor, pebulate, simazine, and 2,4-D.

Figure 10 presents box and whisker plots for the rivers in the Licking River Watershed. Median concentrations in all rivers were below 0.5 μg/L. The North Fork Licking River exhibited the largest IR. MCL and aquatic life criteria were not exceeded at any of the monitoring sites.

Eastern Kentucky Coal Field Region. The Eastern Kentucky Coal Field Region lies east of the Pottsville escarpment from the Ohio River, south to the Kentucky - Tennessee state line. Several of the state's rivers (Cumberland, Kentucky, Licking, Big Sandy, Tygarts Creek, Little Sandy River) have their origins in this region. The region is a highly dissected plateau with entrenched streams in narrow valleys. Agriculture is largely limited to narrow creek and river bottoms. Row crop land use of watersheds in this study is presented in Table 3. In 1996, the region (counties in the monitored watersheds) accounted for 0.5 percent of the state total corn acreage; 0.06 percent of the total soybean acreage; and 2 percent of the total burley tobacco acreage. Pesticide usage is limited to scattered crop areas.

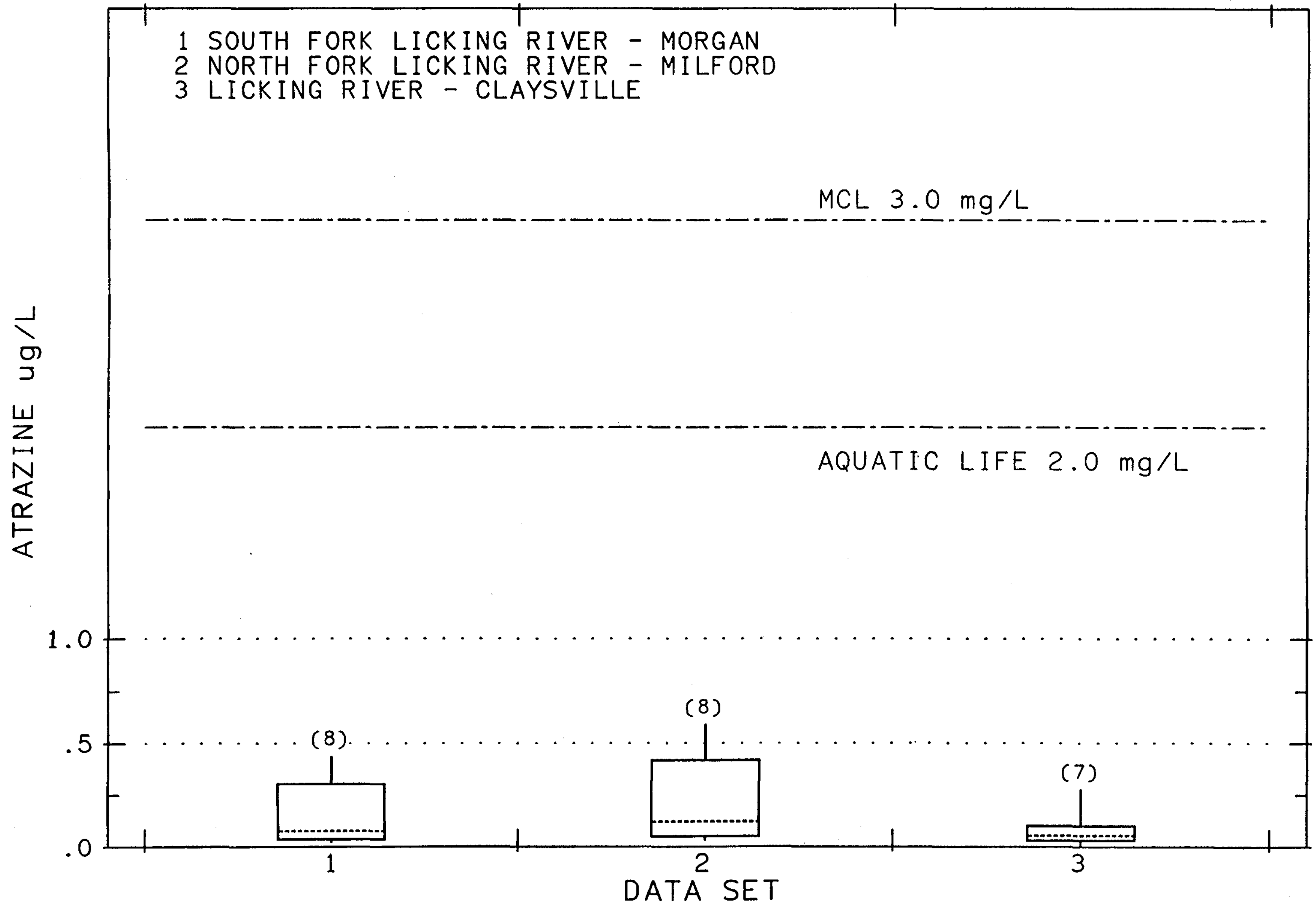
Atrazine was the only pesticide detected in Eastern Kentucky Coal Field rivers. There were no pesticides detected in the Levisa Fork.

Atrazine concentrations in the Little Sandy River and Cumberland River were all less than 0.25 μg/L. There were no excursions above MCL or aquatic life criteria in any of the rivers monitored. This validated the discontinuation of Eastern Kentucky Coal Field sampling sites after the 1996 agricultural growing season.

Comparison to National Water Quality Assessment (NAWQA) Results

The U.S. Geological Survey Pesticide National Synthesis Project (NPSP) has compiled monitoring results from several large river basins across the nation (U.S. Geological Survey, 1999). Approximately 2,200 analyses of 46 targeted pesticides and pesticide degradation products have been conducted. Results from the current study of pesticides in Kentucky Rivers are comparable with those of the NPSP.

FIGURE 10.
ATRAZINE CONCENTRATIONS - LICKING RIVER WATERSHED



NPSP sites included two general types: indicator and integrator sites. Indicator sites represent water quality conditions of streams in relatively homogeneous basins associated with specific environmental settings. Primarily the targeted environmental setting influences water quality at indicator sites.

NPSP indicator sites included both urban and agricultural land-uses. Integrator sites represent water quality conditions of relatively large basins influenced by complex combinations of land-use settings, point sources, and natural influences typical of the region. Integrator sites are downstream of indicator sites and provide a general check on the persistence of water quality influences evident at indicator sites. Integrator sites are generally located in the downstream end of river basins. Using the definition of sites as either indicator or integrator sites, most sites in the current study would be classified as integrator sites. The sites are located at the downstream end of hydrologic units or are rivers within a major hydrologic unit. Agricultural indicator sites in the current study included: Highland Creek, Casey Creek, Cypress Creek, Obion Creek, and Bayou de Chien.

Herbicides most frequently detected in both studies were among the highest in agricultural use, including the herbicides atrazine, metolachlor, simazine, and 2,4-D. Acetochlor, frequently detected in this study was not analyzed in the NPSP. Cyanazine and prometon, listed as commonly found herbicides by the NPSP, were infrequently detected during this study. Cyanazine was not among the leading herbicides according to Kentucky agricultural sales data. Prometon is not listed for agricultural usage but is used extensively for control of vegetation along roadsides and in construction areas. Diazinon was the only insecticide detected during this study. Sites at which diazinon were detected (Panther Creek and Salt River at Shepherdsville) receive runoff from both urban and agricultural land uses. NPSP listed diazinon, carbaryl, malathion, and chlorpyrifos as frequently detected insecticides. Insecticides were prevalent in urban streams as noted by NPSP. They attributed this to intensive application of insecticides to gardens and lawns, liberal irrigation during the growing season, and efficient flow pathways along impervious surfaces and storm drains. Concentrations of most detected pesticides in this study and by NPSP were below 1 μg/L. Maximum concentrations exceeding 1 μg/L were detected during this study for 2,4-D, atrazine, simazine, metolachlor, and cyanazine.

Seasonal patterns observed in this study were typical of those observed at most NPSP integrator and agricultural indicator sites. Seasonal patterns were less evident at NPSP urban indicator sites where low levels of several pesticides persisted throughout the year.

Annual stream loads of pesticides generally accounted for less than 2 percent of the amount applied agriculturally in the NPSP basins. For several herbicides, including atrazine, cyanazine, and metolachlor, the amount transported in streams consistently represented about 1 percent of the amount applied in most integrator and agricultural indicator basins. Using 1 percent as an estimate of pesticide stream transport, and Kentucky sales data for 1997, it is estimated that 18,000 pounds of atrazine and 10,800 pounds of metolachlor were lost from agricultural land to Kentucky rivers in 1997. NPSP found that the amount of other herbicides and all insecticides transported in streams represented a much smaller (10 to 100 times lower) portion of the amount applied in the basins.

SUMMARY

- **Pesticide use in Kentucky**

  Based on sales data, about 4.5 million pounds of the top five herbicides were applied annually to Kentucky croplands in 1996 and 1997. Atrazine, metolachlor, acetochlor, glyphosate, and pendimethalin were the most heavily applied pesticides. Acephate was the most heavily applied insecticide.

- **Loss of applied herbicides to surface waters**

  Up to 32,200 pounds of atrazine and metolachlor were estimated to have been transported annually from treated acreage to surface waters based on sales data and an estimated 1 percent loss of applied product.

- **Pesticides detected in Kentucky rivers**

  Fifteen pesticides were detected in Kentucky rivers during the study. In 1996, ten pesticides were detected. In 1997, fifteen pesticides were detected. Nine of the pesticides were detected in both years. Terbacil was detected only in 1996. Five pesticides (pendimethalin, EPTC, prometon, pebulate, diazinon) were detected only in 1997. DEA was also detected in 1997 (the only year it was analyzed). Of the fifteen pesticides, only one is not a herbicide. Diazinon was the only insecticide detected.

- **Detection frequency**

  Atrazine was the most frequently detected herbicide in both years, followed by metolachlor and simazine. Acetochlor increased in frequency of detection from five sites in 1996 to thirteen sites in 1997.

- **Concentrations of pesticides**

  Pesticide concentrations were generally higher in 1997. Maximum concentrations for most pesticides detected both years occurred in 1997. Highest maximum and median concentrations of atrazine generally were measured in streams of the Jackson Purchase, Western Pennyroyal, and Western Kentucky Coal Field physiographic regions. Atrazine levels generally corresponded to intensity of cash grain farming land use in watersheds.

- **Temporal trends in pesticide concentrations**

  While it is not possible to make statements regarding long-term trends from two years of data, it is possible to make some general statements about year-to-year variations and seasonal trends. Pesticide concentrations varied between 1996 and 1997 in many streams due to climatic conditions. In most streams sampled during this study, maximum concentrations occurred in May and June during the post-application period. However, there were exceptions in 1997 due to record rainfall. Early applied pesticides in the Purchase and Western Kentucky Coal Field regions were transported from fields to streams by a record rainfall event in early March. Highest concentrations of atrazine and other herbicides were detected in April following this rainfall event.

- **Pesticide implications for human health**

  Atrazine exceeded the MCL for drinking water (3 μg/L) in several streams in western Kentucky. For those streams in which the MCL was exceeded, only Tradewater River serves as water supply (Providence withdraws from the Tradewater River at river mile 40.8). The MCL was exceeded once in 1997. Although the MCL is based on the annual mean concentration, results indicate that atrazine may be of concern to public water suppliers seasonally in the Tradewater River watershed.

- **Pesticide implications for aquatic life**

  Atrazine exceeded the Canadian aquatic life criterion (2 μg/L) at least once in several western Kentucky streams. Streams in the Jackson Purchase and Western Kentucky Coal Field regions had the largest number of criterion exceedances. Other herbicides, which exceeded or approached aquatic life criteria included: 2,4-D and metolachlor. Diazinon was the only insecticide detected. On both occasions it was detected, diazinon exceeded the aquatic life criterion.

  Atrazine probably has its greatest affect on primary producers (Larson and others, 1997). Atrazine concentrations of 20 μg/L have been found to affect both photosynthesis and succession, including the establishment of resistant species within the phytoplankton community (deNoyalles and others, 1982). In tributaries of the White River in Indiana (Fenelon, 1998), water quality (high nitrate and atrazine levels) was thought to limit fish communities in view of otherwise excellent habitat conditions. Tributaries having only fair habitat conditions, but with water quality not greatly impaired by agricultural runoff, supported excellent fish communities.

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APPENDIX A

List of Compounds Analyzed During Study

LIST OF COMPOUNDS ANALYZED DURING STUDY

EPA Method 508

Compound	Practical Quantification Limit* µg/L	Compound	Practical Quantification Limit µg/L
1,2,3,4,5,5-Hexachloro-1,3-cyclopentadiene	.04	Technical Chlordane	.01
Hexachlorobene	.01	o,p'-DDE	.01
Hexachlorlcyclohexane, alpha isomer	.01	p,p'-DDE	.01
Hexachlorlcyclohexane, beta isomer	.01	Dieldrin	.01
Hexachlorlcyclohexane, gamma isomer	.01	Endrin	.01
Hexachlorlcyclohexane, delta isomer	.01	o,p'-DDD	.01
Heptachlor	.01	p,p'-DDD	.01
Aldrin	.01	o,p'-DDT	.01
Chlopyrifos	.01	p,p'-DDT	.01
Heptachlor epoxide	.01	Total DDT	.01
Oxychlordane	.01	Methoxychlor	.01
trans-Chlordane	.01	Mirex	.01
cis-Chlordane	.01	Endosulfan I	.01
trans-Nonachlor	.01	Endosulfan II	.01
cis-Nonachlor	.01	Endosulfan sulfate	.01
alpha-Chlordene	.01	Endrin aldehyde	.01
gamma-Chlordene	.01	Endrin ketone	.01
Chlordene	.01	Toxaphene	.1

EPA Method 507

Dichlorvos	.05	Proamide	.05
S-Ethyldiisopropyl thiocarbamate (EPTC)	.05	Disulfoton	.05
S-Ethyldiisobutyl thiocarbamate (Butylate)	.05	Tefluthrin	.05
Mevinphos	.05	Terbacil	.1
Vernolate (S-Propyldipropylthiocarbamate	.05	Acetochlor	.05
Acephate	.4	Alachlor	.05
Pebulate	.05	Metribuzin	.05
Molinate	.05	Simetryn	.05
Tebuthiuron	.4	Ametryn	.05
Propachlor	.05	Prometryn	.05
Ethoprop	.05	Methyl parathion	.05
Cycloate	.05	Terbutryn	.05
Chlorpropham	.05	Malathion	.05
Trifluralin	.05	Bromacil	.05
Benfluralin (Benefin)	.05	Metolachlor	.05
Atrazine desethyl	.05	Triadimefon	.05
Atraton	.05	Parathion	.05
Prometon	.05	Cyanazine	.05
Simazine	.05	MGK 264	.05
Atrazine	.05	Diphenamide	.2
Propazine	.05	Isopropalin (Paarlan)	.2
Profluralin (Tolban)	.05	Pendimethalin	.05
Terbufos	.05	Butachlor	.05
Diazinon	.05	Stirofos	.05
Fonofos	.05	Napropamide	.05

continue EPA Method 507			
Oxyflurfen (Goal)	.05	Oxadiazone	.05
Carboxin	.05	Merphos (Folex)	.05
Norflurazon	.05	Hexazinone	.05
Fenamiphos (Nemacur)	.8		
EPA Method 515.1			
2,2-Dichloropropionic acid (Dalapon)	1.0	2- (2,4,5 - Trichlorophenoxy) Propionic Acid	.05
3,5-Dichlorobenzoic acid	.05	2,4,5 - Trichlorophenoxyacetic Acid	.05
Dicamba	.05	4 - (2,4 - Dichlorophenoxyl) butyric acid (2,4 - DB)	.42
Dichloroprop	.1	Dinoseb	.1
2,4 - D	.1	Bentazone	.1
Pentachlorophenol	.05	Picloram	.05
Chloraben	.1	Acifluorfen	.05
5 - Hydroxydicamba	.1		
EPA Method 531.1			
Aldicarb sulfone	1.0	Aldicarb	1.0
Aldicarb sulfoxide	1.0	Baygon	1.0
Oxamyl	1.0	Carbofuran	1.0
Methomyl	1.0	Carbaryl	1.0
3 - Hydroxycarbofuran	1.0	Methiocarb	1.0
additional EPA Method 508 compounds			
Arochlor 1016	.05	Arochlor 1254	.05
Arochlor 1221	.05	Arochlor 1260	.05
Arochlor 1232	.05	Arochlor 1262	.05
Arochlor 1242	.05	Arochlor 1268	.05
Arochlor 1248	.05		

APPENDIX B

Supplemental Information

SUPPLEMENTAL INFORMATION FOR PESTICIDES DETECTED IN WATER-COLUMN IN 1996 AND 1997					
Pesticide	**Trade Name**	**Crop**	**Application Period**	**Application Method**	**Weeds Controlled**
Acetochlor	Harness, Harness Xtra, Surpass, Surpass 100, TopNotch FulTime 4CS	corn	mid Mar – mid April	Early preplant or preemergent/ early postemergence	Preemergence control of annual grasses, broadleaf weeds, and nutsedge
Alachlor	Lasso EC, Lasso II, Bullet, CropStar, Micro-Tech, Lariat, Partner	corn/soybeans	mid Mar- mid April/ early May- mid June	Early preplant or preemergent	preemergence control of annual grasses, broadleaf weeds, and nutsedge
Atrazine	AAtrex, Atrazine, Bicep II, Bicep II Magnum, Basis Gold, Guardsman, Marksman, Bullet 4 F, Lariet 4 F, Contour, FulTime 4CS, Laddok S12, Sutazine+18.6 G	corn	mid Mar- mid April/ mid April- late April	early preplant or preemergent/ early postemergent	preemergence and postemergence control of broadleaf weeds and certain grasses
Cyanazine	Extrazine, II 90 DF, Extrazine II 4 L, Bladex, CyPro	corn	mid Mar – mid April	early preplant or preemergent or early postemergence	preemergence and postemergence control of broadleaf weeds and certain grasses

2,4-D	various Crossbow Formula 40 High-Dep Scorpion III Weedone 64 Weedone 638 Weedone LV4 Weedone LV6 Weedmaster	corn/soybeans/ winter wheat/ pastures	mid Mar- early April/ mid April- mid May/ late April- mid May/ early Mar- early April	early preplant; early postemergence, to corn & wheat	control of broadleaf weeds and wild garlic
Metolachlor	Bicep II, Bicep II Magnum, Dual II, Dual II Magnum, Turbo, Broadstrike + Dual	corn/soybeans	mid Mar- mid-April/ early May- mid June	early preplant or preemergence	preemergence control of annual grasses and nutsedge
Simazine	Princep, Simazine Pramitol	corn	mid Mar- mid April	early preplant or preemergence/ postemergence	preemergence control of annual grasses
Metribuzin	Canopy 75 DF, Canopy XL 56.3 DF, Lexone, Sencor Salute, Turbo	soybeans/ winter wheat	early May- mid June/ early Mar- early April	preemergence/ postemergence	preemergence control of annual broadleaf weeds/control of emerged annual grasses and certain broadleaf weeds
Pendimethalin	Prowl, Squadron	soybeans tobacco	early May- mid June/ mid April- mid May	preemergence- pre-transplant	preemergence control of annual grasses and certain broadleaf weeds
Dicamba	Banvel	winter	immediately after	postemergence	broadleaf weed

	Clarity Marksman	wheat/corn	winter dormancy/ mid April - mid May	burndown/ post/emergence	control control of emerged broadleaf weeds
Pebulate	Tillman	tobacco	mid April - mid May	pre-transplant	pre-transplant control of grasses and sedges
Terbacil	Geonter, Sinbar	alfalfa, apples		pre and postemergent	control of annual broadleaf weeds
Prometon	Atratol, Pramitol	non-crop use			
EPTC	Eradicane, Eradicane 25G, Eradicane II 90 DF, Eradicane II 4 L	corn		preemergent	control of annual grasses broadleaf weeds and nutsedge

LAND USE INFORMATION

Levisa Fork-Louisa

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
DECIDUOUS FOREST	3,515,616,928.00	868,697.04	93.28321%
EVERGREEN FOREST	38,797,200.00	9,586.66	1.02944%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	15,583,500.00	3,850.63	0.41349%
HIGH INTENSITY RESIDENTIAL	4,261,500.00	1,053.00	0.11307%
LOW INTENSITY RESIDENTIAL	8,850,600.00	2,186.95	0.23484%
MIXED FOREST	106,282,800.00	26,262.12	2.82010%
OPEN WATER	18,210,600.00	4,499.78	0.48320%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	616,500.00	152.34	0.01636%
PASTURE/HAY	20,454,300.00	5,054.19	0.54273%
QUARRIES/STRIP MINES/GRAVEL PITS	29,652,300.00	7,326.98	0.78679%
ROW CROPS	2,671,200.00	660.04	0.07088%
TRANSITIONAL	7,670,700.00	1,895.40	0.20353%
WOODY WETLANDS	88,200.00	21.79	0.00234%
TOTALS	**3,768,756,328.00**	**931,246.93**	**100.00000%**

Little Sandy R-Argillite

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
BARE ROCK/SAND/CLAY	18,000.00	4.448	0.00096%
DECIDUOUS FOREST	1607670944	397,250.10	85.77524%

EMERGENT HERBACEOUS WETLANDS	39,600.00	9.785	0.00211%
EVERGREEN FOREST	34,641,900.00	8,559.90	1.84827%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	6,352,200.00	1,569.61	0.33891%
HIGH INTENSITY RESIDENTIAL	924,300.00	228.391	0.04931%
LOW INTENSITY RESIDENTIAL	3,974,400.00	982.061	0.21205%
MIXED FOREST	94,649,400.00	23,387.55	5.04990%
OPEN WATER	6,018,300.00	1,487.10	0.32110%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	1,097,100.00	271.09	0.05853%
PASTURE/HAY	65,603,700.00	16,210.45	3.50020%
QUARRIES/STRIP MINES/GRAVEL PITS	4,550,400.00	1,124.39	0.24278%
ROW CROPS	40,813,200.00	10,084.80	2.17754%
TRANSITIONAL	7,200,000.00	1,779.10	0.38415%
WOODY WETLANDS	729,900.00	180.356	0.03894%
TOTALS	**1,874,283,344.00**	**463,129.12**	**100.00000%**

Cumberland R-Cumberland Falls			
LANDCOV CLASSIFICATION	**AREA (sq. meters)**	**AREA (acres)**	**% of Total Area**
DECIDUOUS FOREST	3218013032	795,160.10	75.40539%
EMERGENT HERBACEOUS WETLANDS	1,189,800.00	293.996	0.02788%
EVERGREEN FOREST	255,518,100.00	63,137.66	5.98737%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	18,907,200.00	4,671.91	0.44304%
HIGH INTENSITY RESIDENTIAL	5,062,500.00	1,250.93	0.11863%
LOW INTENSITY RESIDENTIAL	23,377,500.00	5,776.50	0.54779%
MIXED FOREST	535,626,000.00	132,351.40	12.55094%
OPEN WATER	15,737,400.00	3,888.66	0.36876%

OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	10,121,400.00	2,500.96	0.23717%
PASTURE/HAY	122,544,900.00	30,280.43	2.87151%
QUARRIES/STRIP MINES/GRAVEL PITS	7,436,700.00	1,837.58	0.17426%
ROW CROPS	24,785,100.00	6,124.31	0.58077%
TRANSITIONAL	14,058,900.00	3,473.91	0.32943%
WOODY WETLANDS	15,237,900.00	3,765.23	0.35706%
TOTALS	**4,267,616,432.00**	**1,054,513.58**	**100.00000%**

SF Licking R-Morgan

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
BARE ROCK/SAND/CLAY	900.00	0.22	0.00004%
DECIDUOUS FOREST	493,929,900.00	122,048.40	20.55421%
EMERGENT HERBACEOUS WETLANDS	202,500.00	50.04	0.00843%
EVERGREEN FOREST	48,961,800.00	12,098.29	2.03748%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	12,804,300.00	3,163.90	0.53283%
HIGH INTENSITY RESIDENTIAL	5,284,800.00	1,305.86	0.21992%
LOW INTENSITY RESIDENTIAL	18,532,800.00	4,579.39	0.77122%
MIXED FOREST	241,614,900.00	59,702.22	10.05447%
OPEN WATER	5,619,600.00	1,388.58	0.23385%
OTHER SOURCES URBAN/RECREATIONAL PARKS/LAWNS/GOLF COURSES	9,628,200.00	2,379.10	0.40067%
PASTURE/HAY	1,235,978,096.00	305,406.00	51.43352%
QUARRIES/STRIP MINES/GRAVEL PITS	749,700.00	185.25	0.03120%
ROW CROPS	321,982,200.00	79,560.71	13.39885%
TRANSITIONAL	208,800.00	51.59	0.00869%

WOODY WETLANDS	7,560,900.00	1,868.27	0.31464%
TOTALS	**2,403,059,396.00**	**593,787.82**	**100.00000%**

Licking River-Claysville

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
BARE ROCK/SAND/CLAY	7,200.00	1.78	0.00024%
DECIDUOUS FOREST	1,656,924,288.00	409,420.40	54.74471%
EMERGENT HERBACEOUS WETLANDS	612,000.00	151.22	0.02022%
EVERGREEN FOREST	81,641,700.00	20,173.39	2.69744%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	8,442,000.00	2,085.99	0.27892%
HIGH INTENSITY RESIDENTIAL	1,491,300.00	368.50	0.04927%
LOW INTENSITY RESIDENTIAL	6,066,900.00	1,499.11	0.20045%
MIXED FOREST	285,296,400.00	70,495.77	9.42618%
OPEN WATER	8,287,200.00	2,047.74	0.27381%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	3,240,000.00	800.59	0.10705%
PASTURE/HAY	674,082,004.00	166,563.40	22.27164%
QUARRIES/STRIP MINES/GRAVEL PITS	1,457,100.00	360.05	0.04814%
ROW CROPS	283,143,600.00	69,963.83	9.35505%
TRANSITIONAL	937,800.00	231.73	0.03098%
WOODY WETLANDS	15,008,400.00	3,708.53	0.49588%
TOTALS	**3,026,637,892.00**	**747,872.02**	**100.00000%**

NF Licking R-Milford

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
DECIDUOUS FOREST	334,636,204.00	82,687.48	42.39349%
EVERGREEN FOREST	26,601,300.00	6,573.09	3.36999%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	2,380,500.00	588.21	0.30157%
HIGH INTENSITY RESIDENTIAL	142,200.00	35.14	0.01801%
LOW INTENSITY RESIDENTIAL	1,621,800.00	400.74	0.20546%
MIXED FOREST	82,560,600.00	20,400.45	10.45922%
OPEN WATER	502,200.00	124.09	0.06362%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	151,200.00	37.36	0.01915%
PASTURE/HAY	243,395,100.00	60,142.11	30.83458%
ROW CROPS	96,770,700.00	23,911.71	12.25942%
TRANSITIONAL	330,300.00	81.62	0.04184%
WOODY WETLANDS	265,500.00	65.60	0.03363%
TOTALS	**789,357,604.00**	**195,047.60**	**100.00000%**

Rolling Fork-Lebanon Junction

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
BARE ROCK/SAND/CLAY	1,800.00	0.45	0.00005%
DECIDUOUS FOREST	1,622,055,584.00	400,804.40	43.07178%
EMERGENT HERBACEOUS WETLANDS	1,800,900.00	445.00	0.04782%
EVERGREEN FOREST	159,470,100.00	39,404.52	4.23454%

HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	15,549,300.00	3,842.18	0.41289%
HIGH INTENSITY RESIDENTIAL	1,941,300.00	479.69	0.05155%
LOW INTENSITY RESIDENTIAL	15,335,100.00	3,789.25	0.40721%
MIXED FOREST	449,793,900.00	111,142.50	11.94374%
OPEN WATER	10,959,300.00	2,708.01	0.29101%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	19,915,200.00	4,920.98	0.52882%
PASTURE/HAY	1,063,170,000.00	262,705.70	28.23123%
QUARRIES/STRIP MINES/GRAVEL PITS	1,642,500.00	405.86	0.04361%
ROW CROPS	329,086,800.00	81,316.23	8.73851%
TRANSITIONAL	5,031,000.00	1,243.14	0.13359%
WOODY WETLANDS	70,182,900.00	17,341.96	1.86363%
TOTALS	**3,765,935,684.00**	**930,549.86**	**100.00000%**

Salt River-Glensboro

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
DECIDUOUS FOREST	68,788,800.00	16,997.48	15.26466%
EVERGREEN FOREST	17,038,800.00	4,210.23	3.78102%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	3,036,600.00	750.33	0.67384%
HIGH INTENSITY RESIDENTIAL	1,126,800.00	278.43	0.25004%
LOW INTENSITY RESIDENTIAL	6,403,500.00	1,582.28	1.42097%
MIXED FOREST	48,571,200.00	12,001.78	10.77825%
OPEN WATER	862,200.00	213.05	0.19133%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	4,534,200.00	1,120.39	1.00617%
PASTURE/HAY	234,386,996.00	57,916.23	52.01193%

QUARRIES/STRIP MINES/GRAVEL PITS	851,400.00	210.38	0.18893%
ROW CROPS	63,647,100.00	15,726.98	14.12369%
TRANSITIONAL	53,100.00	13.12	0.01178%
WOODY WETLANDS	1,340,100.00	331.13	0.29738%
TOTALS	**450,640,796.00**	**111,351.81**	**100.00000%**

Salt River-Shepherdsville

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
BARE ROCK/SAND/CLAY	4,500.00	1.11	0.00020%
DECIDUOUS FOREST	682,763,396.00	168,708.50	29.74562%
EMERGENT HERBACEOUS WETLANDS	1,189,800.00	294.00	0.05184%
EVERGREEN FOREST	41,996,700.00	10,377.24	1.82965%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	26,635,500.00	6,581.54	1.16042%
HIGH INTENSITY RESIDENTIAL	8,750,700.00	2,162.27	0.38124%
LOW INTENSITY RESIDENTIAL	52,965,000.00	13,087.47	2.30750%
MIXED FOREST	208,067,400.00	51,412.75	9.06477%
OPEN WATER	9,352,800.00	2,311.05	0.40747%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	31,242,600.00	7,719.94	1.36113%
PASTURE/HAY	608,460,300.00	150,348.50	26.50850%
QUARRIES/STRIP MINES/GRAVEL PITS	1,895,400.00	468.35	0.08258%
ROW CROPS	606,257,108.00	149,804.10	26.41252%
TRANSITIONAL	1,856,700.00	458.78	0.08089%
WOODY WETLANDS	13,902,300.00	3,435.21	0.60567%
TOTALS	**2,295,340,204.00**	**567,170.81**	**100.00000%**

Beech Fork-Maud

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
DECIDUOUS FOREST	350,286,300.00	86,554.56	28.79460%
EMERGENT HERBACEOUS WETLANDS	1,800.00	0.45	0.00015%
EVERGREEN FOREST	89,390,700.00	22,088.14	7.34819%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	3,073,500.00	759.45	0.25265%
HIGH INTENSITY RESIDENTIAL	288,900.00	71.39	0.02375%
LOW INTENSITY RESIDENTIAL	2,427,300.00	599.78	0.19953%
MIXED FOREST	193,040,100.00	47,699.55	15.86848%
OPEN WATER	2,688,300.00	664.27	0.22099%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	1,823,400.00	450.56	0.14989%
PASTURE/HAY	488,696,404.00	120,755.20	40.17232%
ROW CROPS	82,816,200.00	20,463.60	6.80774%
TRANSITIONAL	858,600.00	212.16	0.07058%
WOODY WETLANDS	1,108,800.00	273.98	0.09115%
TOTALS	**1,216,500,304.00**	**300,593.07**	**100.00000%**

Nolin River-Millerstown

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
BARE ROCK/SAND/CLAY	3,600.00	0.89	0.00032%
DECIDUOUS FOREST	228,286,800.00	56,408.89	20.52957%
EMERGENT HERBACEOUS WETLANDS	153,000.00	37.81	0.01376%

EVERGREEN FOREST	29,788,200.00	7,360.56	2.67882%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	10,661,400.00	2,634.40	0.95877%
HIGH INTENSITY RESIDENTIAL	2,995,200.00	740.10	0.26936%
LOW INTENSITY RESIDENTIAL	12,449,700.00	3,076.28	1.11959%
MIXED FOREST	90,951,300.00	22,473.76	8.17915%
OPEN WATER	6,334,200.00	1,565.16	0.56963%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	21,811,500.00	5,389.55	1.96148%
PASTURE/HAY	436,575,600.00	107,876.40	39.26077%
QUARRIES/STRIP MINES/GRAVEL PITS	447,300.00	110.53	0.04023%
ROW CROPS	259,940,700.00	64,230.47	23.37618%
TRANSITIONAL	1,269,900.00	313.79	0.11420%
WOODY WETLANDS	10,321,200.00	2,550.33	0.92817%
TOTALS	**1,111,989,600.00**	**274,768.91**	**100.00000%**

Green River-Munfordville

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
DECIDUOUS FOREST	1,135,360,800.00	280,543.80	34.96398%
EMERGENT HERBACEOUS WETLANDS	342,000.00	84.51	0.01053%
EVERGREEN FOREST	95,596,200.00	23,621.50	2.94393%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	15,066,900.00	3,722.98	0.46399%
HIGH INTENSITY RESIDENTIAL	2,691,900.00	665.16	0.08290%
LOW INTENSITY RESIDENTIAL	18,305,100.00	4,523.13	0.56371%
MIXED FOREST	325,276,200.00	80,374.65	10.01704%
OPEN WATER	10,364,400.00	2,561.01	0.31918%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF	24,069,600.00	5,947.52	0.74124%

COURSES			
PASTURE/HAY	1,159,658,104.00	286,547.60	35.71223%
QUARRIES/STRIP MINES/GRAVEL PITS	1,160,100.00	286.66	0.03573%
ROW CROPS	447,845,400.00	110,661.10	13.79162%
TRANSITIONAL	1,139,400.00	281.54	0.03509%
WOODY WETLANDS	10,353,600.00	2,558.34	0.31884%
TOTALS	**3,247,229,704.00**	**802,379.50**	**100.00000%**

Drakes Creek-Bowling Green			
LANDCOV CLASSIFICATION	**AREA (sq. meters)**	**AREA (acres)**	**% of Total Area**
DECIDUOUS FOREST	185,824,800.00	45,916.68	23.22400%
EMERGENT HERBACEOUS WETLANDS	352,800.00	87.18	0.04409%
EVERGREEN FOREST	11,682,000.00	2,886.58	1.45999%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	5,999,400.00	1,482.43	0.74979%
HIGH INTENSITY RESIDENTIAL	1,283,400.00	317.12	0.16040%
LOW INTENSITY RESIDENTIAL	7,042,500.00	1,740.18	0.88016%
MIXED FOREST	51,342,300.00	12,686.51	6.41665%
OPEN WATER	1,211,400.00	299.33	0.15140%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	9,405,000.00	2,323.94	1.17542%
PASTURE/HAY	316,951,200.00	78,317.57	39.61190%
QUARRIES/STRIP MINES/GRAVEL PITS	292,500.00	72.28	0.03656%
ROW CROPS	190,625,400.00	47,102.89	23.82396%
TRANSITIONAL	622,800.00	153.89	0.07784%

WOODY WETLANDS	17,505,900.00	4,325.65	2.18785%
TOTALS	**800,141,400.00**	**197,712.23**	**100.00000%**

Pond River-Sacramento

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
BARE ROCK/SAND/CLAY	45,900.00	11.34	0.00222%
DECIDUOUS FOREST	838,098,016.00	207,091.20	40.61426%
EMERGENT HERBACEOUS WETLANDS	9,222,300.00	2,278.80	0.44691%
EVERGREEN FOREST	22,399,200.00	5,534.77	1.08547%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	19,081,800.00	4,715.05	0.92470%
HIGH INTENSITY RESIDENTIAL	2,124,900.00	525.06	0.10297%
LOW INTENSITY RESIDENTIAL	14,765,400.00	3,648.48	0.71553%
MIXED FOREST	62,753,400.00	15,506.15	3.04103%
OPEN WATER	50,355,900.00	12,442.77	2.44025%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	13,577,400.00	3,354.93	0.65796%
PASTURE/HAY	250,263,900.00	61,839.36	12.12780%
QUARRIES/STRIP MINES/GRAVEL PITS	9,022,500.00	2,229.43	0.43723%
ROW CROPS	593,785,796.00	146,722.50	28.77489%
TRANSITIONAL	43,702,200.00	10,798.67	2.11781%
WOODY WETLANDS	134,357,400.00	33,199.26	6.51096%
TOTALS	**2,063,556,012.00**	**509,897.77**	**100.00000%**

Cypress Creek-Rumsey

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
BARE ROCK/SAND/CLAY	1,800.00	0.45	0.00044%
DECIDUOUS FOREST	108,936,900.00	26,917.94	26.49800%
EMERGENT HERBACEOUS WETLANDS	3,807,000.00	940.70	0.92602%
EVERGREEN FOREST	5,519,700.00	1,363.90	1.34262%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	4,527,900.00	1,118.83	1.10138%
HIGH INTENSITY RESIDENTIAL	1,213,200.00	299.78	0.29510%
LOW INTENSITY RESIDENTIAL	6,633,000.00	1,638.99	1.61342%
MIXED FOREST	9,848,700.00	2,433.58	2.39561%
OPEN WATER	11,625,300.00	2,872.57	2.82776%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	4,600,800.00	1,136.84	1.11910%
PASTURE/HAY	56,305,800.00	13,912.97	13.69592%
QUARRIES/STRIP MINES/GRAVEL PITS	2,367,900.00	585.10	0.57597%
ROW CROPS	154,369,804.00	38,144.26	37.54918%
TRANSITIONAL	15,311,700.00	3,783.47	3.72444%
WOODY WETLANDS	26,044,200.00	6,435.43	6.33503%
TOTALS	**411,113,704.00**	**101,584.80**	**100.00000%**

Green River-Livermore

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
BARE ROCK/SAND/CLAY	152,100.00	37.58	0.00576%

DECIDUOUS FOREST	1,378,651,516.00	340,660.10	52.17045%
EMERGENT HERBACEOUS WETLANDS	4,842,900.00	1,196.66	0.18326%
EVERGREEN FOREST	41,085,000.00	10,151.96	1.55472%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	13,343,400.00	3,297.11	0.50494%
HIGH INTENSITY RESIDENTIAL	2,113,200.00	522.17	0.07997%
LOW INTENSITY RESIDENTIAL	15,439,500.00	3,815.05	0.58426%
MIXED FOREST	142,810,200.00	35,287.92	5.40417%
OPEN WATER	44,838,000.00	11,079.32	1.69674%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	11,142,900.00	2,753.37	0.42167%
PASTURE/HAY	345,897,000.00	85,469.98	13.08931%
QUARRIES/STRIP MINES/GRAVEL PITS	16,134,300.00	3,986.73	0.61055%
ROW CROPS	483,622,200.00	119,501.40	18.30106%
TRANSITIONAL	33,465,600.00	8,269.24	1.26639%
WOODY WETLANDS	109,053,000.00	26,946.63	4.12675%
TOTALS	**2,642,590,816.00**	**652,975.22**	**100.00000%**

Rough River-Livermore

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
DECIDUOUS FOREST	900,230,400.00	222,443.90	56.05252%
EMERGENT HERBACEOUS WETLANDS	571,500.00	141.22	0.03558%
EVERGREEN FOREST	12,154,500.00	3,003.34	0.75680%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	8,158,500.00	2,015.94	0.50799%
HIGH INTENSITY RESIDENTIAL	726,300.00	179.47	0.04522%
LOW INTENSITY RESIDENTIAL	5,700,600.00	1,408.60	0.35495%
MIXED FOREST	43,098,300.00	10,649.44	2.68350%

OPEN WATER	11,941,200.00	2,950.63	0.74351%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	5,642,100.00	1,394.14	0.35130%
PASTURE/HAY	195,781,500.00	48,376.95	12.19026%
QUARRIES/STRIP MINES/GRAVEL PITS	2,888,100.00	713.64	0.17983%
ROW CROPS	374,734,800.00	92,595.70	23.33272%
TRANSITIONAL	6,526,800.00	1,612.75	0.40639%
WOODY WETLANDS	37,893,600.00	9,363.38	2.35943%
TOTALS	**1,606,048,200.00**	**396,849.09**	**100.00000%**

Panther Creek-Sorgho

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
DECIDUOUS FOREST	284,194,800.00	70,223.57	28.68761%
EMERGENT HERBACEOUS WETLANDS	1,973,700.00	487.70	0.19923%
EVERGREEN FOREST	6,392,700.00	1,579.62	0.64530%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	9,009,000.00	2,226.09	0.90940%
HIGH INTENSITY RESIDENTIAL	5,380,200.00	1,329.43	0.54310%
LOW INTENSITY RESIDENTIAL	17,484,300.00	4,320.31	1.76493%
MIXED FOREST	16,589,700.00	4,099.26	1.67462%
OPEN WATER	5,844,600.00	1,444.18	0.58997%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	18,235,800.00	4,506.00	1.84078%
PASTURE/HAY	209,352,600.00	51,730.32	21.13278%
QUARRIES/STRIP MINES/GRAVEL PITS	2,062,800.00	509.71	0.20823%
ROW CROPS	376,695,008.00	93,080.06	38.02490%
TRANSITIONAL	2,693,700.00	665.60	0.27191%

WOODY WETLANDS	34,744,500.00	8,585.25	3.50723%
TOTALS	**990,653,408.00**	**244,787.10**	**100.00000%**

Highland Creek-Uniontown

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
BARE ROCK/SAND/CLAY	44,100.00	10.90	0.00726%
DECIDUOUS FOREST	50,407,200.00	12,455.45	8.29950%
EMERGENT HERBACEOUS WETLANDS	541,800.00	133.88	0.08921%
EVERGREEN FOREST	1,960,200.00	484.36	0.32275%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	2,030,400.00	501.71	0.33430%
HIGH INTENSITY RESIDENTIAL	271,800.00	67.16	0.04475%
LOW INTENSITY RESIDENTIAL	4,635,900.00	1,145.52	0.76330%
MIXED FOREST	6,450,300.00	1,593.85	1.06204%
OPEN WATER	9,243,900.00	2,284.14	1.52200%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	412,200.00	101.85	0.06787%
PASTURE/HAY	129,538,800.00	32,008.60	21.32844%
ROW CROPS	344,652,300.00	85,162.41	56.74667%
TRANSITIONAL	1,048,500.00	259.08	0.17263%
WOODY WETLANDS	56,115,000.00	13,865.83	9.23928%
TOTALS	**607,352,400.00**	**150,074.73**	**100.00000%**

Casey Creek-Waverly

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
DECIDUOUS FOREST	8,186,400.00	2,022.83	10.10318%
EVERGREEN FOREST	244,800.00	60.49	0.30212%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	918,900.00	227.06	1.13405%
HIGH INTENSITY RESIDENTIAL	188,100.00	46.48	0.23214%
LOW INTENSITY RESIDENTIAL	1,750,500.00	432.54	2.16037%
MIXED FOREST	638,100.00	157.67	0.78751%
OPEN WATER	2,133,000.00	527.06	2.63243%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	234,000.00	57.82	0.28879%
PASTURE/HAY	16,146,900.00	3,989.84	19.92756%
ROW CROPS	49,695,300.00	12,279.54	61.33111%
TRANSITIONAL	891,900.00	220.39	1.10073%
TOTALS	**81,027,900.00**	**20,021.71**	**100.00000%**

Tradewater River-Sullivan

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
DECIDUOUS FOREST	986,856,308.00	243,848.90	40.04587%
EMERGENT HERBACEOUS WETLANDS	3,473,100.00	858.19	0.14094%
EVERGREEN FOREST	65,486,700.00	16,181.54	2.65740%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	10,554,300.00	2,607.93	0.42828%

HIGH INTENSITY RESIDENTIAL	3,401,100.00	840.40	0.13801%
LOW INTENSITY RESIDENTIAL	25,931,700.00	6,407.64	1.05229%
MIXED FOREST	103,752,900.00	25,636.99	4.21021%
OPEN WATER	31,614,300.00	7,811.79	1.28288%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	6,958,800.00	1,719.50	0.28238%
PASTURE/HAY	443,978,100.00	109,705.50	18.01629%
QUARRIES/STRIP MINES/GRAVEL PITS	13,926,600.00	3,441.22	0.56513%
ROW CROPS	595,828,792.00	147,227.30	24.17827%
TRANSITIONAL	23,931,000.00	5,913.27	0.97110%
WOODY WETLANDS	148,621,500.00	36,723.87	6.03094%
TOTALS	**2,464,315,200.00**	**608,924.04**	**100.00000%**

Clarks River-Paducah

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
DECIDUOUS FOREST	348,031,800.00	85,997.48	24.40784%
EMERGENT HERBACEOUS WETLANDS	131,400.00	32.47	0.00922%
EVERGREEN FOREST	17,818,200.00	4,402.82	1.24961%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	6,587,100.00	1,627.65	0.46196%
HIGH INTENSITY RESIDENTIAL	3,127,500.00	772.80	0.21933%
LOW INTENSITY RESIDENTIAL	30,769,200.00	7,602.97	2.15788%
MIXED FOREST	54,486,900.00	13,463.53	3.82122%
OPEN WATER	5,716,800.00	1,412.60	0.40092%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	2,318,400.00	572.87	0.16259%
PASTURE/HAY	553,712,404.00	136,820.50	38.83245%
QUARRIES/STRIP MINES/GRAVEL PITS	900.00	0.22	0.00006%

ROW CROPS	319,365,900.00	78,914.23	22.39747%
TRANSITIONAL	1,623,600.00	401.19	0.11386%
WOODY WETLANDS	82,211,400.00	20,314.16	5.76557%
TOTALS	**1,425,901,504.00**	**352,335.48**	**100.00000%**

Obion Creek-Oakton

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
DECIDUOUS FOREST	102,642,300.00	25,362.56	12.34404%
EMERGENT HERBACEOUS WETLANDS	21,600.00	5.34	0.00260%
EVERGREEN FOREST	4,136,400.00	1,022.09	0.49745%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	999,900.00	247.07	0.12025%
HIGH INTENSITY RESIDENTIAL	350,100.00	86.51	0.04210%
LOW INTENSITY RESIDENTIAL	3,945,600.00	974.94	0.47451%
MIXED FOREST	21,885,300.00	5,407.78	2.63198%
OPEN WATER	3,002,400.00	741.88	0.36108%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	148,500.00	36.69	0.01786%
PASTURE/HAY	366,674,400.00	90,604.00	44.09727%
QUARRIES/STRIP MINES/GRAVEL PITS	396,000.00	97.85	0.04762%
ROW CROPS	273,478,500.00	67,575.61	32.88928%
TRANSITIONAL	586,800.00	145.00	0.07057%
WOODY WETLANDS	53,244,900.00	13,156.63	6.40338%
TOTALS	**831,512,700.00**	**205,463.96**	**100.00000%**

Bayou de Chein-Clinton

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
BARE ROCK/SAND/CLAY	15,300.00	3.78	0.00289%
DECIDUOUS FOREST	42,361,200.00	10,467.31	7.99693%
EMERGENT HERBACEOUS WETLANDS	4,500.00	1.11	0.00085%
EVERGREEN FOREST	2,130,300.00	526.39	0.40216%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	643,500.00	159.01	0.12148%
HIGH INTENSITY RESIDENTIAL	73,800.00	18.24	0.01393%
LOW INTENSITY RESIDENTIAL	1,116,900.00	275.98	0.21085%
MIXED FOREST	11,552,400.00	2,854.56	2.18086%
OPEN WATER	1,007,100.00	248.85	0.19012%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	19,800.00	4.89	0.00374%
PASTURE/HAY	236,775,600.00	58,506.45	44.69839%
ROW CROPS	197,521,200.00	48,806.82	37.28796%
TRANSITIONAL	189,000.00	46.70	0.03568%
WOODY WETLANDS	36,307,800.00	8,971.53	6.85417%
TOTALS	**529,718,400.00**	**130,891.62**	**100.00000%**

Little River-Cadiz

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
DECIDUOUS FOREST	264,744,896.00	65,417.57	26.43564%
EMERGENT HERBACEOUS WETLANDS	1,093,500.00	270.20	0.10919%

EVERGREEN FOREST	13,988,700.00	3,456.56	1.39682%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	10,144,800.00	2,506.75	1.01299%
HIGH INTENSITY RESIDENTIAL	3,717,000.00	918.46	0.37115%
LOW INTENSITY RESIDENTIAL	15,814,800.00	3,907.78	1.57916%
MIXED FOREST	27,998,100.00	6,918.24	2.79570%
OPEN WATER	5,724,900.00	1,414.60	0.57165%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF COURSES	9,184,500.00	2,269.46	0.91710%
PASTURE/HAY	299,100,600.00	73,906.74	29.86617%
QUARRIES/STRIP MINES/GRAVEL PITS	495,900.00	122.54	0.04952%
ROW CROPS	311,472,000.00	76,963.68	31.10149%
TRANSITIONAL	14,989,500.00	3,703.86	1.49675%
WOODY WETLANDS	23,000,400.00	5,683.32	2.29666%
TOTALS	**1,001,469,596.00**	**247,459.75**	**100.00000%**

Red River-Keysburg

LANDCOV CLASSIFICATION	AREA (sq. meters)	AREA (acres)	% of Total Area
DECIDUOUS FOREST	78,303,600.00	19,348.55	8.84305%
EMERGENT HERBACEOUS WETLANDS	3,956,400.00	977.61	0.44681%
EVERGREEN FOREST	9,477,900.00	2,341.96	1.07037%
HIGH INTENSITY COMMERCIAL/INDUSTRIAL/TRANSPORTATION	1,139,400.00	281.54	0.12868%
HIGH INTENSITY RESIDENTIAL	209,700.00	51.82	0.02368%
LOW INTENSITY RESIDENTIAL	2,318,400.00	572.87	0.26182%
MIXED FOREST	20,157,300.00	4,980.80	2.27642%
OPEN WATER	1,662,300.00	410.75	0.18773%
OTHER SOURCES URBAN/RECREATIONAL: PARKS/LAWNS/GOLF	2,106,000.00	520.39	0.23784%

COURSES			
PASTURE/HAY	390,195,900.00	96,416.09	44.06597%
ROW CROPS	351,251,100.00	86,792.96	39.66782%
TRANSITIONAL	18,000.00	4.45	0.00203%
WOODY WETLANDS	24,685,200.00	6,099.63	2.78777%
TOTALS	**885,481,200.00**	**218,799.41**	**100.00000%**

APPENDIX D
Comparison of US EPA & Canadian Aquatic Life Criteria

Comparison of USEPA & Canadian Aquatic Life Criteria

Canadian guidelines are designed to protect all forms of aquatic life at all life stages. They differ from EPA's water-quality criteria, which are designed to protect 95 percent of genera tested.

US EPA WATER QUALITY CRITERIA FOR THE PROTECTION OF AQUATIC ORGANISMS: An EPA chronic water-quality criterion represents the highest concentration without adverse effects after extended exposure (4 days). If the 4-day average concentration of a pollutant does not exceed this value more than once every three years, then freshwater aquatic life and their uses should not be unacceptably affected (except possibly where a locally important species is very sensitive). This chronic criterion (CCC) is set equal to the lowest of the following: (1) the final chronic value, which is based on chronic toxicity, discussed further below, (2) the final plant value, which is based on plant toxicity tests; and (3) the final residue value, which protects both marketability of fish and wildlife that consume aquatic organisms; it is the maximum permissible concentration in fish (either the FDA action level or a concentration derived from wildlife feeding studies) divided by the bioconcentration factor.

For most water-soluble pesticides, the final chronic value (FCV) is usually lower than either the final plant value or final residue value, and therefore the CCC is set equal to the FCV. The FCV is derived from chronic toxicity data, either directly (if chronic data are available for at least 1 species in at least 8 families) or indirectly (by calculation of an acute-chronic ratio). The FCV is an estimate of the concentration of a pollutant that is lower than the chronic-toxicity values for 95 percent of the genera with which acceptable toxicity tests have been conducted.

Thus, the EPA chronic criteria are designed to protect 95 percent of the genera tested, not necessarily every important sensitive species. Criteria should not be exceeded more than once every 3 years (based on the premise that 3 years is sufficient time for aquatic ecosystems to recover following an excursion over the CCC). For more information, see: Stephan, C.R., Mount, D.I., Hansen, D.J., Gentile, J.H., Chapman, G.A., and Brungs, W.A., 1985, Guidelines for deriving numerical national water quality criteria for the protection of aquatic organisms and their uses: U.S. Environmental Protection Agency PB-85-227049.

CANADIAN WATER QUALITY GUIDELINES FOR THE PROTECTION OF AQUATIC LIFE: Canadian freshwater guidelines require the following toxicity data:
(1) at least 3 studies with at least 3 species of fish resident in North America, including at least one warm-water and one cold-water species; at least 2 studies must be chronic (partial or full life cycle studies; (2) at least 2 chronic studies on 2 or more invertebrate species from different classes, at least one of which is a planktonic species resident in North America; (3) at least one study on a freshwater vascular plant or algal species resident in North America. However, interim guidelines can be set on the basis of fewer studies and test species. (Note that a number of Canadian guidelines for pesticides are interim guidelines).

Canadian guidelines are preferably derived from the most sensitive LOEL from a chronic study using a nonlethal endpoint for the most sensitive life stage of a native Canadian species. The most sensitive LOEL is divided by a safety factor of 10 to arrive at the guideline value. However, when this type of data is unavailable, the guideline can be derived from acute studies by dividing the most sensitive LC50 (or EC50) by an acute/chronic ratio or by an appropriate application factor. For more information, see:
Canadian Council of Ministers of the Environment, 1996, Canadian water quality guidelines (rev. ed.): Ottawa, Ontario, Canadian Council of Resource and Environment Ministers, loose-leaf (originally published 1987), variously paged, 22 appendixes. See especially App. 9, A protocol for the derivation of water quality guidelines for the protection of aquatic life (April 1991).
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APPENDIX E

1996 Data

CONCENTRATIONS of PESTICIDES DETECTED in WATER COLUMN in 1996 JACKSON PURCHASE REGION (mg/l)			
CLARKS RIVER NEAR PADUCAH			
	Pre-application	**Post-application**	**Fall**
Herbicides	**3/28/96**	**6/18/96**	**10/10/96**
2,4-D	no det.	no det.	0.020
Alachlor	no det.	0.022	no det.
Atrazine	0.067	0.897	0.130
Metolachlor	0.040	0.449	0.003
Terbacil	no det.	0.071	no det.
BAYOU DE CHIEN near CLINTON			
	Pre-application	**Post-application**	**Fall**
Herbicides	**3/28/96**	**6/18/96 (sample lost)**	**10/10/96**
Atrazine	no det.		0.038
Metolachlor	0.092		no det.

CONCENTRATIONS of PESTICIDES DETECTED in WATER COLUMN in 1996
WESTERN PENNYROYAL REGION (mg/l)

GREEN RIVER at MUNFORDVILLE

	Pre-application	Post-application	Fall
Herbicides	**4/10/96**	**6/05/96**	**10/17/96**
Atrazine	0.024	0.253	0.060
Metolachlor	no det.	0.054	no det.
Simazine	no det.	0.174	no det.

NOLIN RIVER at MILLERSTOWN

	Pre-application	Post-application	Fall
Herbicides	**4/04/96**	**6/05/96**	**9/20/96**
2,4-D	no det.	0.280	no det.
Acetochlor	no det.	0.098	no det.
Alachlor	no det.	0.164	no det.
Atrazine	0.057	2.52	0.056
Metolachlor	0.004	0.256	no det.
Simazine	no det.	1.29	no det.

LITTLE RIVER near CADIZ

	Pre-application	Post-application	Fall
Herbicides	**4/08/96**	**6/18/96**	**9/20/96**
2,4-D	no det.	0.354	no det.
Acetochlor	no det.	0.154	no det.
Alachlor	no det.	0.025	no det.
Atrazine	0.126	1.07	0.395
Metolachlor	0.001	0.314	0.017
Simazine	no det.	0.053	no det.

RED RIVER near KEYSBURG			
	Pre-application	**Post-application**	**Fall**
Herbicides	**4/09/96**	**6/18/96**	**10/08/96**
Acetochlor	no det.	0.013	no det.
Alachlor	no det.	0.014	no det.
Atrazine	0.204	0.776	0.210
Metolachlor	0.013	0.118	0.011
Simazine	no det.	0.028	no det.
DRAKES CREEK near BOWLING GREEN			
	Pre-application	**Post-application**	**Fall**
Herbicides	**4/10/96**	**6/05/96**	**9/20/96**
Acetochlor	no det.	0.029	no det.
Alachlor	no det.	0.020	no det.
Atrazine	0.044	1.49	0.020
Cyanazine	no det.	0.151	no det.
Metolachlor	no det.	0.334	no det.
Simazine	no det.	0.090	no det.

CONCENTRATIONS of PESTICIDES DETECTED in WATER COLUMN in 1996 WESTERN KENTUCKY COAL FIELD REGION (mg/l)			
GREEN RIVER AT LIVERMORE			
	Pre-application	**Post-application**	**Fall**
Herbicides	**4/09/96**	**6/18/96**	**10/09/96**
Alachlor	no det.	0.030	no det.
Atrazine	no det.	0.418	0.250
Metolachlor	no det.	0.097	0.026
Simazine	no det.	0.130	no det.
POND RIVER near SACRAMENTO			
	Pre-application	**Post-application**	**Fall**
Herbicides	**4/08/96**	**6/19/96**	**10/09/96**
Atrazine	no det.	2.15	0.067
Metolachlor	no det.	0.515	no det.
Simazine	no det.	0.426	no det.
HIGHLAND CREEK near UNIONTOWN			
	Pre-application	**Post-application**	**Fall**
Herbicides	**4/8/96**	**6/18/96**	**10/24/96**
2,4-D	no det.	0.377	no det.
Alachlor	no det.	0.015	no det.
Atrazine	no det.	3.81	0.154
Metolachlor	no det.	no det.	0.077
Simazine	0.027	0.395	no det.

TRADEWATER RIVER at SULLIVAN			
	Pre-application	**Post-application**	**Fall**
Herbicides	**4/08/96**	**6/18/96**	**10/09/96**
Atrazine	no det.	1.84	no det.
Dicamba	0.041	no det.	no det.
Metolachlor	no det.	0.426	no det.
Metribuzin	no det.	0.064	no det.
Simazine	no det.	0.360	no det.

CONCENTRATIONS of PESTICIDES DETECTED IN WATER COLUMN IN 1996 SALT RIVER BASIN (mg/l)			
SALT RIVER at SHEPHERDSVILLE			
	Pre-application	**Post-application**	**Fall**
Herbicides	**4/04/96**	**6/04/96**	**10/17/96**
Atrazine	no det.	0.352	0.111
Metolachlor	no det.	0.088	no det.
Simazine	no det.	0.116	0.004
SALT RIVER at GLENSBORO			
	Pre-application	**Post-application**	**Fall**
Herbicides	**4/04/96**	**6/06/96**	**10/24/96**
Atrazine	no det.	0.839	0.022
Metolachlor	no det.	0.305	no det.
Simazine	no det.	0.143	no det.
ROLLING FORK near LEBANON JUNCTION			
	Pre-application	**Post-application**	**Fall**
Herbicides	**4/04/96**	**6/04/96**	**10/17/96**
Acetochlor	no det.	0.286	no det.
Atrazine	no det.	0.352	0.023
Metolachlor	no det.	0.089	no det.
Simazine	no det.	0.116	no det.

BEECH FORK near MAUD			
	Pre-application	Post-application	Fall
Herbicides	**4/04/96**	**6/04/96**	**10/17/96**
Alachlor	no det.	0.027	no det.
Atrazine	0.002	0.051	no det.
Metolcahlor	no det.	0.055	no det.
Simazine	no det.	0.077	no det.

CONCENTRATIONS of PESTICIDES DETECTED IN WATER COLUMN IN 1996 LICKING RIVER BASIN (mg/l)			
LICKING RIVER at CLAYSVILLE			
	Pre-application	**Post-application**	**Fall**
Herbicides	**3/26/96**	**6/17/96**	**10/24/96**
2,4-D	no det.	0.084	no det.
Atrazine	no det.	0.011	no det.
Metolachlor	0.107	no det.	no det.
NORTH FORK LICKING RIVER near MILFORD			
	Pre-application	**Post-application**	**Fall**
Herbicides	**3/26/96**	**6/17/96**	**10/24/96**
2,4-D	0.082	no det.	1.51
Alachlor	no det.	0.028	no det.
Atrazine	no det.	0.584	0.035
Metolachlor	no det.	0.139	no det.
Simazine	no det.	0.237	no det.
SOUTH FORK LICKING RIVER at MORGAN			
	Pre-application	**Post-application**	**Fall**
Herbicides	**3/26/96**	**6/17/96**	**10/24/96**
2,4-D	0.090	no det.	0.130
Atrazine	no det.	0.432	0.024
Metolachlor	no det.	0.077	no det.
Simazine	no det.	0.200	no det.

CONCENTRATIONS of PESTICIDES DETECTED in WATER COLUMN in 1996 EASTERN KENTUCKY COAL FIELD REGION (μg/l)			
CUMBERLAND RIVER at CUMBERLAND FALLS			
	Pre-application	**Post-application**	**Fall**
Herbicides	**3/25/96**	**6/18/96**	**10/24/96**
Atrazine	no det.	0.048	no det.
LEVISA FORK near LOUISA			
	Pre-application	**Post-application**	**Fall**
Herbicides	**not sampled**	**6/18/96**	**not sampled**
None Detected	no det.	no det.	no det.
LITTLE SANDY RIVER near ARGILLITE			
	Pre-application	**Post-application**	**Fall**
Herbicides	**4/09/96**	**6/18/96**	**not sampled**
Atrazine	no det.	0.065	no det.
	no det.	no det.	no det.

APPENDIX F

1997 Data

CONCENTRATIONS of PESTICIDES DETECTED in WATER COLUMN in 1997
JACKSON PURCHASE REGION (mg/l)

CLARKS RIVER at PADUCAH

	APRIL	MAY	JUNE	JULY	FALL
Herbicides	**4/14/97**	**5/20/97**	**6/16/97**	**7/14/97**	**10/21/97**
2,4-D	1.19	no det.	no det.	no det.	no det.
Acetochlor	.170	.061	.092	no det.	no det.
Atrazine	9.36	5.65	2.47	.450	.041
Atrazine desethyl	.137	.452	.889	.180	.061
Cyanazine	.140	no det.	no det.	no det.	no det.
Metolachlor	1.76	.711	1.54	.210	.004
Simazine	no det.	.747	.592	no det.	no det.

OBION CREEK at OAKTON

	APRIL	MAY	JUNE	JULY	FALL
Herbicides	**4/14/97**	**5/21/97**	**6/17/97**	**7/15/97**	**10/21/97**
2,4-D	1.21	no det.	4.08	no det.	no det.
Acetochlor	.793	no det.	.036	no det.	no det.
Alachlor	.211	no det.	.047	no det.	no det.
Atrazine	20.6	7.75	.207	.333	.034
Atrazine desethyl	.198	.563	.769	.100	no det.
Cyanazine	1.24	no det.	no det.	no det.	no det.
Metolachlor	5.87	.308	.762	.198	.035
Simazine	no det.	.406	.125	no det.	no det.

BAYOU DE CHIEN near CLINTON					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/14/97**	**5/21/97**	**6/17/97**	**7/15/97**	**10/21/97**
Acetochlor	.440	no det.	no det.	no det.	no det.
Atrazine	1.77	.147	.876	.138	no det.
Atrazine desethyl	.028	.116	.517	.066	no det.
Cyanazine	.018	no det.	no det.	no det.	no det.
Metolachlor	.349	.273	.877	.007	no det.
Metribuzin	no det.	no det.	.432	no det.	no det.
Simazine	no det.	no det.	.076	no det.	no det.

CONCENTRATIONS of PESTICIDES in WATER COLUMN in 1997
WESTERN KENTUCKY PENNYROYAL REGION (mg/l)

GREEN RIVER at MUNFORDVILLE					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/22/97**	**5/27/97**	**6/25/97**	**7/23/97**	**11/04/97**
Atrazine	no det.	.265	.209	.039 / .040	.079
Atrazine desethyl	no det.	.049	no det.	.026 / .022	.028
Metolachlor	no det.	no det.	.038	no det.	.003
Simazine	no det.	no det.	.107	no det.	no det.
NOLIN RIVER at MILLERSTOWN					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/22/97**	**5/27/97**	**6/24/97**	**7/23/97**	**11/04/97**
Alachlor	no det.	.064	no det.	no det.	no det.
Atrazine	.034	1.49	.402	1.77	no det.
Atrazine desethyl	.061	.242	.184	.164	no det.
Cyanazine	no det.	.176	no det.	no det.	no det.
Metolachlor	no det.	.107	no det.	.021	no det.
Simazine	no det.	.557	.120	no det.	no det.
LITTLE RIVER near CADIZ					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/15/97**	**5/21/97**	**6/17/97**	**7/15/97**	**11/05/97**
Acetochlor	no det.	.153	no det.	no det.	no det.
Atrazine	.365	5.72	1.00	.205	.299
Atrazine desethyl	.196	.969	.513	.269	.114
Metolachlor	.068	3.92	.256	.100	no det.
Pebulate	no det.	.015	no det.	no det.	no det.
Simazine	no det.	.231	.077	no det.	no det.

RED RIVER near KEYSBURG					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/15/97**	**5/19/97**	**6/16/97**	**7/15/97**	**11/04/97**
Atrazine	.160	.781	.828	.205	.015
Atrazine desethyl	.198	.559	.498	.373	.105
Metolachlor	.029	.064	.195	.180	no det.
Simazine	no det.	no det.	.097	no det.	no det.

DRAKES CREEK near BOWLING GREEN					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/22/97**	**5/28/97**	**6/26/97**	**7/24/97**	**11/06/97**
Atrazine	.056	.347	.080	.028	no det.
Atropine desethyl	.033	.111	.020	no det.	no det.
Metolachlor	.052	.036	.018	no det.	no det.

CONCENTRATIONS of PESTICIDES DETECTED in WATER COLUMN in 1997 WESTERN KENTUCKY COALFIELD REGION (mg/l)					
GREEN RIVER at LIVERMORE					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/25/97**	**5/19/97**	**6/18/97**	**6/15/97**	**11/05/97**
Acetochlor	no det.	.005	.013	no det.	no det.
Atrazine	.044	1.36	.318	.195	.111
Atrazine desethyl	.016	.055	.085	.040	.020
Metolachlor	no det.	.215	.090	.052	no det.
Simazine	no det.	no det.	.109	no det.	no det.
ROUGH RIVER at LIVERMORE					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/25/97**	**5/19/97**	**6/18/97**	**7/15/97**	**11/05/97**
Acetochlor	no det.	no det.	.036	no det.	no det.
Atrazine	.037	.308	.524	1.99	.563
Atrazine desethyl	.014	.058	.066	.302	.102
Metolachlor	no det.	.042	.187	.731	.110
Simazine	no det.	.193	.130	no det.	no det.
POND RIVER near SACRAMENTO					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/15/97**	**5/19/97**	**6/26/97**	**7/15/97**	**10/22/97**
Atrazine	.032	1.54 / .404	.745	.325	.072
Atrazine desethyl	no det.	.096 / .068	.131	.118	.062
Metolachlor	.023	.261 / .060	.124	.060	.023
Simazine	no det.	no det.	.100	no det.	no det.

CYPRESS CREEK Near RUMSEY					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/15/97**	**5/19/97**	**6/16/97**	**7/15/97**	**10/22/97**
2,4-D	.370	no det.	no det.	no det.	no det.
Acetochlor	.033	.067	.080	no det.	no det.
Atrazine	.160	.800	2.14	.048	no det.
Atrazine desethyl	.050	.052	.314	.020	no det.
Metolachlor	.050	.051	.265	.027	no det.
Pendimethalin	no det.	no det.	.031	no det.	no det.
Simazine	.095	no det.	.638	.007	no det.

PANTHER CREEK at SORGHO					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/15/97**	**5/19/97**	**6/16/97**	**7/15/97**	**10/22/97**
2,4-D	.490	no det.	no det.	.437	no det.
Acetochlor	.147	.172	.180	no det.	no det.
Alachlor	no det.	no det.	.057	no det.	no det.
Atrazine	.794	.198	3.96	.160	.017
Atrazine desethyl	.046	.156	.809	.025	no det.
EPTC	no det.	.021	no det.	no det.	no det.
Metolachlor	.207	.597	.191	.103	.003
Simazine	no det.	no det.	.418	no det.	no det.
Insecticides	no det.	no det.	no det.	no det.	no det.
Diazinon	.018	no det.	no det.	no det.	no det.

HIGHLAND CREEK near UNIONTOWN					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/15/97**	**5/19/97**	**6/16/97**	**7/15/97**	**10/20/97**
2,4-D	1.29	no det.	.257	.160	no det.
Acetochlor	.162	no det.	.053 / .059	no det.	no det.
Atrazine	8.22	2.61	1.66 / 2.39	.337	.043
Atrazine desethyl	.131	.430	.455 / .719	.073	.052
Metolachlor	1.83	1.17	.944 / 1.44	.145	.006
Simazine	no det.	no det.	.141	no det.	no det.

CASEY CREEK near WAVERLY					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/15/97**	**5/19/97**	**6/16/97**	**7/15/97**	**10/20/97**
2,4-D	1.10	no det.	.234	.510	no det.
Acetochlor	no det.	.028	.193	no det.	no det.
Atrazine	5.93	1.19	.892	.765	.063
Atrazine desethyl	.155	no det.	.307	.174	.048
Dicamba	no det.	no det.	.105	no det.	no det.
Metolachlor	1.64	.356	.504	.785	.006
Prometon	no det.	no det.	no det.	.079	no det.
Simazine	no det.	.227	.096	no det.	.020

TRADEWATER at SULLIVAN					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/15/97**	**5/21/97**	**6/17/97**	**7/15/97**	**10/20/97**
2,4-D	no det.	no det.	no det.	.510	no det.
Acetochlor	no det.	.815	no det.	no det.	no det.
Alachlor	no det.	no det.	no det.	.537	no det.
Atrazine	.625	9.65	.949	.595	.021
Atrazine desethyl	.042	.331	.176	.208	no det.
Metolachlor	.293	1.62	.116	.759	.005
Metribuzin	no det.	no det.	no det.	.106	no det.
Simazine	no det.	.719	.165	no det.	no det.

CONCENTRATIONS of PESTICIDES DETECTED in WATER COLUMN in 1997 SALT RIVER BASIN (mg/l)					
SALT RIVER / SHEPHERDSVILLE					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/21/97**	**5/13/97**	**6/10/97**	**7/19/97**	**10/16/97**
2.4-D	no det.	no det.	1.19	no det.	no det.
Acetochlor	no det.	.048 / .052	.014	no det.	no det.
Atrazine	.877	.932 / 1.00	.460	.202	.129
Atrazine desethyl	.022	.063 / .050	.129	.065	.060
Metolachlor	2.42	.393 / .426	.099	.053	.011
Prometon	no det.	no det.	no det.	no det.	.206
Simazine	no det.	no det.	.221	.058	.051
Insecticides	no det.	no det.	no det.	no det.	no det.
Diazinon	no det.	no det.	no det.	.018	no det.
SALT RIVER at GLENSBORO					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/29/97**	**5/27/97**	**6/19/97**	**7/23/97**	**10/09/97**
Atrazine	.014	.834	.828	.142	.089
Atrazine desethyl	.024	.076	.098	.061	.064
Metolachlor	no det.	.260	.084	.018	no det.
Simazine	no det.	no det.	.428	no det.	no det.

ROLLING FORK near LEBANON JUNCTION					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/21/97**	**5/13/97**	**6/10/97**	**7/19/97**	**10/16/97**
2,4-D	no det.	no det.	no det.	no det.	no det.
Atrazine	no det.	.243	.092	.113	.040
Atrazine desethyl	no det.	no det.	.050	.037	.051
Metolachlor	no det.	no det.	.013	no det.	no det.
Simazine	no det.	no det.	.063	no det.	no det.

BEECH FORK near MAUD					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/21/97**	**5/13/97**	**6/10/97**	**7/19/97**	**10/16/97**
Atrazine	no det.	.109	.127	.058	.023
Atrazine desethyl	no det.	no det.	.066	.029	no det.
Metolachlor	no det.	no det.	.020	no det.	no det.

CONCENTRATIONS of PESTICIDES DETECTED in WATER COLUMN in 1997
LICKING RIVER BASIN (mg/l)

LICKING RIVER at CLAYSVILLE					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/18/97**	**5/14/97**	**6/11/97**	**7/21/97**	**10/27/97**
Atrazine	no det.	.002	.273	.054	.030
Metolachlor	no det.	no det.	.050	no det.	no det.
Simazine	no det.	no det.	.143	no det.	no det.
NORTH FORK LICKING RIVER near MILFORD					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/18/97**	**5/14/97**	**6/11/97**	**7/21/97**	**10/14/97**
2,4-D	no det.	no det.	.201	no det.	no det.
Acetochlor	no det.	no det.	.019	no det.	no det.
Atrazine	no det.	.144	.499	.202	no det.
Atrazine desethyl	no det.	.010	.130	.045	no det.
Metolachlor	no det.	no det.	.038	no det.	no det.
Simazine	no det.	no det.	.283	no det.	no det.
SOUTH FORK LICKING RIVER at MORGAN					
	APRIL	**MAY**	**JUNE**	**JULY**	**FALL**
Herbicides	**4/18/97**	**5/14/97**	**6/11/97**	**7/21/97**	**10/14/97**
Atrazine	no det.	.034	.370	.065	.089
Atrazine desethyl	.014	no det.	.139	.045	.093
Metolachlor	no det.	no det.	.048	no det.	no det.
Pebulate	no det.	no det.	.038	no det.	no det.
Simazine	no det.	no det.	.276	no det.	.105